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## The Muscular Mechanism of the Male Metasoma and Genitalia of *Megachile fortis* Cresson (Hymenoptera: Megachilidae)<sup>1</sup>

By ROLAND L. FISCHER<sup>2</sup>

Kansas State College, Manhattan

### Introduction

The terminology pertaining to the structure of the male genitalia of the Hymenoptera has been subject to much confusion. Several systems, many purely descriptive in nature, have previously been set forth. Others were based on the various concepts of the ontogeny of the male genitalia, or on the comparative morphology of the adults. The investigation reported here began as an attempt to synthesize the various terminologies and to evolve a workable set of terms pertaining to the structure of the male genitalia of the megachilid bees. Accordingly, a study was conducted on the myology of the group with the thought that perhaps an understanding of the comparative musculature might be of value in determining the homologies of the insect genitalia. This paper reports the results of a phase of the investigation on the morphology of the male metasoma, the muscular mechanism of the male metasoma and genitalia, and the gross structure of the internal reproductive organs of *Megachile* (*Phaenosarsus*) *fortis* Cresson. A second portion of the study, pertaining to the comparative morphology of the male genitalia and associated sterna of the Megachilidae, will be published later.

### The Male Metasoma

The definitive abdomen of *Megachile fortis* consists of nine segments. The first segment of the definitive abdomen is fused with the thorax, being a characteristic feature of the aculeate Hymenoptera, to form what has most frequently been termed the propodeum. To differentiate between the complete abdomen and that portion consisting of segments II through IX, Michener (1944b) proposed the term *metasoma*. The metasoma thus consists of the second through ninth segments. The thorax and the propodeum collectively constitute the *mesosoma*. Throughout the present paper the metasomal segments have been consistently numbered from II through IX. The metasoma is comparatively rather short, robust, rounded posteriorly, and somewhat depressed ventrally.

The third through sixth metasomal sterna are similar to one another. Each is more or less rectangular in shape, slightly bowed, broadly emarginate on the anterior margin and convex on the posterior margin. Sternum VI differs from this general pattern in the presence of a median basal semi-membranous area and an infolded apical margin with a narrow membranous band anterior to the infolding (Fig. 5). A strong well-defined *antecosta* (Fig. 4), on which the longitudinal muscles are attached, is found along the anterior margin of the sternal plates. The *antecosta* is reduced on the seventh and ninth sternal plates, and completely lacking on the eighth. The *acrosternite*, which extends anteriorly from the *antecosta* as a narrow marginal flange in many insects, is lacking on all of the sternal plates of this bee. On the lateral anterior margins of each sternum is a rounded somewhat produced sternal apodeme (Figs. 4 and 5) to which are

<sup>1</sup>A portion of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Entomology at Kansas State College. Contribution No. 662, Department of Entomology, Kansas Agricultural Experiment Station, Manhattan.

<sup>2</sup>Formerly Graduate Assistant at Kansas State College, now located at Michigan State University, East Lansing.

attached the accessory dorsoventral, the lateral ventral, and the external ventral muscles.

Two fairly well-defined areas and frequently a third may be distinguished for each sternum. MacGillivray (1923) proposed the terms "presternite, medasternite, and poststernite" for these areas. Due, however, to the possible confusion of this terminology with the various sternal areas of the mesosomal region, it seems best to adopt with various modifications the terminology of Michener (1944b). The *gradulus* (Fig. 4), as proposed by Michener, is a distinct transverse ridge on the outer surface of the sclerite which, although more conspicuous on the terga, is also well-defined on the sterna. Thus, the area basad of the gradulus is the *pregradular area*, and that area posterior to the gradulus is the *postgradular area*. The gradulus is in close apposition to the antecostal ridge mesally, curving very gradually to the lateral margins of the sternum, and then bending sharply and extending posteriorly. The pregradular area is thus rather small, the major expanse of the sternum being composed of the generally exposed postgradular area which is usually punctate and more or less covered with short pile.

Along the apical margin of the second through sixth sterna is the *duplication* (Fig. 5). The duplication is the internal lamina produced by the infolding of the apical portion of the sternum. The duplication apparently facilitates the sliding movement of one segment over the following segment upon two opposing sclerotic surfaces.

The second sternum is constricted and strengthened basally by the enlarged antecostal ridge.

The eighth sternum is greatly reduced and is present only as two small inconspicuous sclerites situated laterally in the intersegmental membrane. In the past various authors have either misinterpreted these sclerites or have completely missed them. The presence of four muscles (Fig. 6) homologous to those found in other metasomal segments confirms the identity of these small sclerites as remnants of the eighth sternum.

The ninth sternum has been variously termed by hymenopterists "hypotome," "hypandrium," "hypopygidium," and "subgenital plate." This structure in *Megachile fortis* is an elongate shield-shaped sclerite that is closely associated with the genital capsule (Figs. 1 and 5). Anteriorly, the ninth sternum is differentiated into a broad apodeme, known as the *spiculum*.

The third through fifth terga are similar to the sterna in general organization, except that they extend laterally and overlap the sterna to a certain extent. A conspicuous acrotergite (Figs. 4 and 5) is found on the fourth through seventh tergal plates of *Megachile fortis*. The sixth and seventh terga slope caudally. The eighth tergum is fairly well developed but is partially hidden with only an apical flared portion protruding from the apex of the metasoma (Fig. 5). The ninth tergum is small, band-like, with a median longitudinal membranous area.

Between each of the sterna is found the *intersegmental membrane* (Figs. 4 and 5). A similar membrane is found between each of the terga. This membrane is attached posteriorly to the acrotergite or acrosternite or, if these structures are lacking, on the antecosta and anteriorly on the forward margin of the duplication of the preceding segment. The intersegmental membrane is folded upon itself in a non-extended individual, whereas, in an extended individual the membrane becomes taut. A very short *pleural membrane* extends between each sternum and tergum along their lateral margins.

### Terminology of the Male Genitalia

It is beyond the realm of this discussion to present a lengthy discourse on the various systems of terminology set forth previously by various authors. Rather, the terminology of Michener (1944a) has been adopted. Because of various refinements and additions to his system of terminology, the terms employed in this paper are defined below:

**Aedeagal apodemes.** The aedeagal apodemes (Figs. 7, 8, and 9) are the basal ventral extensions of the penis valves and serve for muscular attachment. In the family Megachilidae they usually extend well into the cavity of the gonobase, but frequently may exceed the genital foramen. Apically the aedeagal apodemes are usually somewhat enlarged. They have been termed, by various authors, the penis valve apodemes, but since the muscles that are attached to these apodemes function in the movement of the entire aedeagus in the family, it seems best to term them the aedeagal apodemes.

**Aedeagus.** The aedeagus is a collective term for the penis and the penis valves.

**Endophallus.** The endophallus (Fig. 9) is the small membranous invaginated area at the apex of the penis, into which the ejaculatory duct opens. During copulation it is everted and becomes the functional intromittent organ.

**Genital foramen.** The genital foramen is the anterior opening of the external genital capsule.

**Gonobase.** The gonobase (Figs. 6, 7, and 9) is the secondarily differentiated fused basal portion of the gonocoxites, being more or less annular or produced somewhat anteriorly to form a bulbous structure.

**Gonocoxal apodeme.** The gonocoxal apodeme (Figs. 8 and 9) is the structure produced by the dorsal fusion of the gonocoxites which serve for attachment of muscles.

**Gonocoxites.** The gonocoxites are the basal portions of the outer claspings organ, the gonoforceps.

**Gonocoxopodites.** The gonocoxopodites is a collective term for all the structures of the gonopod, including the gonobase, gonocoxites, penis valves, and volsellae.

**Gonoforceps.** There is some evidence to indicate that a gonostylus may be present in the Megachilidae for there is in many species a definite membranous area separating the anterior and the posterior portions of the outer claspers; however, the antagonistic muscles typically inserted on the styli are lacking. The absence of muscles may indicate that the membrane is a secondary modification and not the articulation point between the stylus and the gonocoxite. Since the presence of a gonostylus remains in doubt, it seems best to adopt a term which is somewhat more inclusive but yet adequately delineates the basal gonocoxite from the posterior claspings organ. Michener (1944a) has defined the gonoforceps as "the fused gonocoxites and gonostyli, or a generalized term for both of these structures when present" and the term would appear to apply in this instance.

**Gonopods.** The gonopods are the segmental appendages of the ninth abdominal segment.

**Gonopore.** The gonopore is the external opening of the ejaculatory duct and is found at the proximal end of the endophallus.

**Penis.** The penis (Fig. 2) is the median membranous intromittent organ. In the Megachilidae the penis is fused at the sides to the penis valves.

*Penis valves.* The penis valves (Figs. 3, 8, and 9) are the mesal basal processes of the gonocoxopodites. The membranous penis is attached along the inner aspect of the valves so that the penis valves function as support for the penis as well as a guide for the penis during copulation.

*Penis valve bridge.* The penis valve bridge (Figs. 3 and 9) is the dorso-basal sclerotized connection between the lateral penis valves. Medially the bridge may be unfused or simply fused, but more frequently is provided with a small apodeme.

*Volsellae.* The volsellae (Figs. 2, 3, and 9) are processes of the gonocoxopodites found laterad of the valves. Snodgrass (1941) stated that true volsellae are absent in the Megachilidae and termed these structures the "ventral lobes of the parameres." He further stated that these lobes "have none of the features of a volsella, being entirely continuous with the parameral plates and not provided with muscles." While it is true that in many of the Osmiini and Megachilini the volsellae appear as ventral plates of the gonocoxite, in many of the Anthidiini these structures also assume the heavily sclerotized nature of volsellae of other groups of bees. In the Anthidiini the volsellae also have the same origin as they do among other groups of bees. Likewise, they are articulate structures, separated from the gonocoxites by a membranous area. While the volsellae of the Megachilinae whose myology was studied were not muscled, the musculature of the volsellae of other groups of Hymenoptera, according to Snodgrass, is variable as to the number of muscles which activate the volsellae. Thus, in the specimens studied there may have been a complete loss of the volsellar musculature. Popov (1945) also concluded that these structures are true volsellae, basing his arguments primarily upon the presence of a distinct longitudinal keel on the inner side of the volsellae. Of this keel, Snodgrass stated that "typically each volsellar plate is strengthened by an internal longitudinal ridge, the external groove of which divides the plate into a lateral and a mesal area." Since the structures are articulate structures in many of the species, possess a longitudinal keel or ridge, and have the same origin in many members of the family as they do in other groups of bees, it would seem that these structurally similar members of the Megachilidae are homologous with the volsellae of other groups of Hymenoptera.

#### Internal Reproductive Organs

To better understand the functioning of the external reproductive organs and to explore for additional taxonomic characters, the internal male reproductive organs of three bees were studied. These included, *Megachile* (*Litomegachile*) *texana* Cresson, *Megachile* (*Phaenoserus*) *fortis* Cresson, and *Osmia* (*Osmia*) *lignaria* Say. The internal reproductive systems of these bees consist of the paired testes, the vasa deferentia, the seminal vesicles, and the median ejaculatory duct which terminates in the gonopore. No distinctive sac-like accessory glands, as found associated with the male reproductive organs of many insects, were noted. The internal reproductive systems of these three bees are illustrated in Figures 1, 2, and 3.

Each *testis* is composed of an elongate intricately coiled tube which may possibly be a single sperm tube. The testis from each side of the body is closely apposed to that of the other side, and they are found within a common sheath. If each testis is composed of but a single sperm tube, the sheath is probably homologous with the *peritoneal sheath* of Snodgrass (1935); if otherwise, the homologies of this sheath are not clearly understood. Further research involving the sectioning of this organ should clarify the exact homologies of this sheath. Pending further investigation the sheath will here be termed the peritoneal sheath. In like manner, the homologies of the tube leading from the testis to the seminal

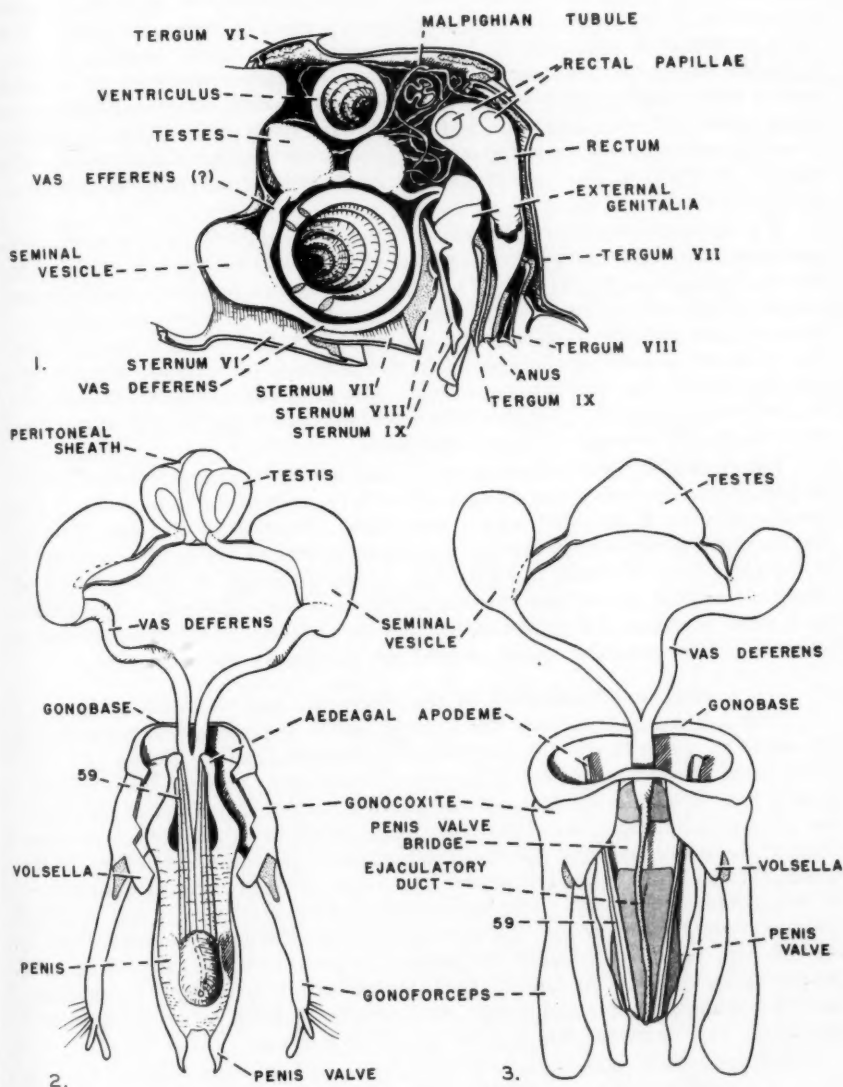


Fig. 1. Parasagittal section of the sixth through ninth metasomal segments of *Megachile* (*Litomegachile*) *texana* Cresson illustrating the internal reproductive system in relation to other internal organs.

Fig. 2. Ventral view of the internal and external reproductive organs of *Osmia* (*Osmia*) *lignaria* Say.

Fig. 3. Ventral view of the internal and external reproductive organs with the ventral membrane of the penis removed of *Megachile* (*Phaenosarus*) *fortis* Cresson.

vesicle are not clearly understood. If each testis consists of but a single sperm tube, this tube would be the *vas efferens* (Fig. 1), whereas if the testis consists of more than a single sperm tube, it would be a portion of the *vas deferens*. The testes in *Megachile fortis* and *M. texana* are grouped so closely together and the peritoneal sheath so thick that at first glance the testes appear to be a fused median organ, but by dissecting away the sheath the coiled nature and distinctness of each testis is at once apparent. In *Osmia lignaria* the sheath is more transparent, revealing and assuming the shape of the coiled testes within. Considerable variation in the gross shape of the testes was noted amongst different individuals of the same species.

The anterior portion of the *vas deferens* (*vas efferens* ?) is a short tube continuous with each testis and opening by means of a short nipple-like projection into the seminal vesicle (Fig. 2). The peritoneal sheath completely envelopes this portion of the *vas deferens*. The *seminal vesicles* of *M. fortis* and *texana* are unilateral and globular in appearance, whereas in *O. lignaria* they are reniform. The posterior portion of the *vasa deferentia* proceeds posteriorly. On the left side the *vas deferens* extends beneath the *ventriculus* and on the right side over the *ventriculus* (Fig. 1). The two *vasa deferentia* come together and fuse as they enter the genital foramen of the genital capsule.

The ejaculatory duct extends from the juncture of the *vasa deferentia* through the penis and terminates in the male gonopore at the apex of the endophallus. The ejaculatory duct is provided with a muscularis consisting of an inner layer of circular muscles and an outer layer of longitudinal muscles. The retractor muscle of the penis (59) in *Osmia lignaria* (Fig. 2) has its origin, as in the species of *Megachile* studied, on the inner surface of the penis valve apodeme. The retractor muscle, however, differs markedly from its homolog in *Megachile* in that it forms an almost complete sheath around the ejaculatory duct (Fig. 3).

#### Muscular Mechanism of the Metasoma and Genitalia

With but minor variations the musculature of the metasomal segments of the males of *Andrena* sp., *Colletes inequalis inequalis* Say, *Megachile* (*Phaenosarus*) *fortis* Cresson, *Megachile* (*Litomegachile*) *texana* Cresson, *Osmia* (*Osmia*) *lignaria* Say, *Melissodes* sp., *Xylocopa virginica* (Linnaeus), and that of the honey bee as figured by Snodgrass (1942) have been found to be essentially the same. Thus, if the above sampling of bees in any manner indicates the myology of the group, the following discussion on the mechanism of the metasomal musculature of *Megachile fortis* Cress. is perhaps representative of the bees and possibly other aculeate Hymenoptera. To eliminate the lengthy muscle terminology in the text and possible confusion with figure references, the muscles have been designated by numbers in *italics*. Each muscle has its own number, which is used throughout the text and figures, and may be referred to in the annotated descriptive list of muscles found at the end of this section.

The metasomal musculature of *Megachile* (*Phaenosarus*) *fortis* Cresson (Figs. 4, 5, and 6) follows a definite pattern which is repeated in segments III through VI. Modifications in this general pattern of musculature have occurred in the propodeum and the morphological second segment, due to the attachment of the metasoma to the mesosoma. The copulatory function of segments VII through IX have likewise resulted in modifications in the muscular pattern of these segments. There are 136 muscles in the metasoma of this bee, consisting of 61 paired or multiple muscles. In addition to the muscles of the genitalia, the muscles of the metasoma may be conveniently classified into four functional categories: dilators, extensors, contractors, and compressors of the metasoma.

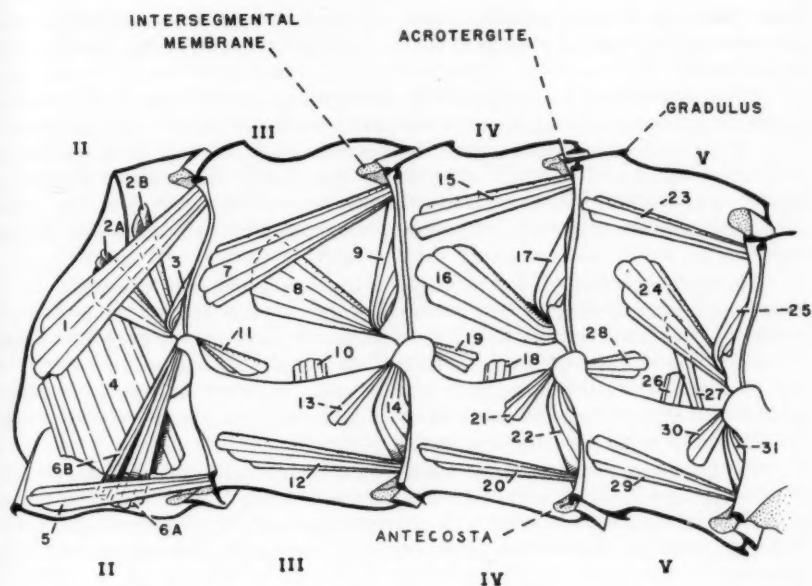


Fig. 4. Sagittal section through the male metasoma of *Megachile (Phaenosarus) fortis* Cresson illustrating the musculature of segments II through V.

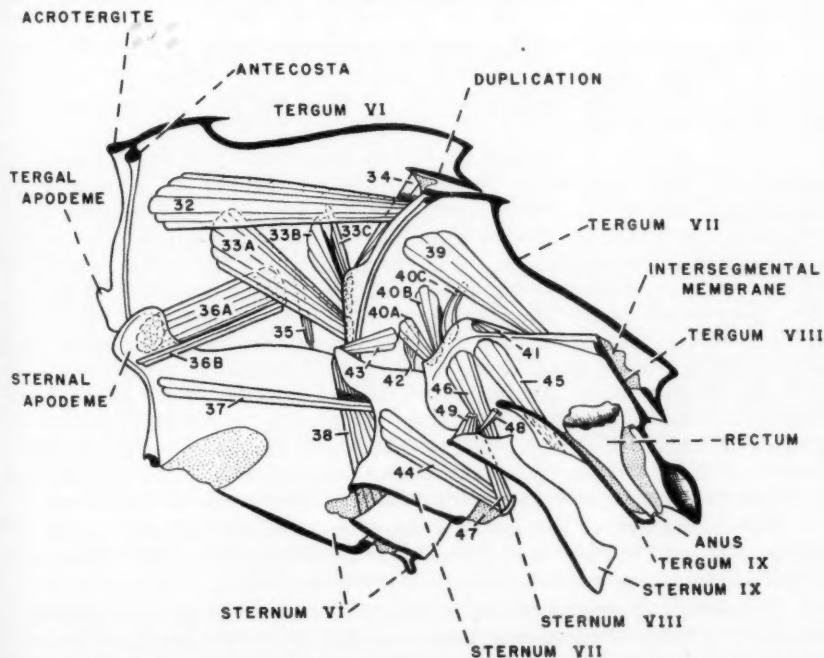


Fig. 5. Sagittal section (greatly enlarged) through the male metasoma of *Megachile (Phaenosarus) fortis* Cresson illustrating the musculature of segments VI through IX.

This classification closely follows that of Snodgrass (1942); however, muscle names have been altered to employ terms that seem more befitting their function and position.

While the musculature of many of the segments is dissimilar, there is enough similarity in the various segments to warrant a discussion of the muscular mechanism of the more generalized segments (segments III and IV). Thus, only those muscles of segments III and IV (Fig. 4) are specifically mentioned. The homologs of these muscles function in a similar manner, except where otherwise stated, in their respective segments. Variations in the general pattern of muscles in other segments are noted later following the discussion of segments III and IV.

The contractors of the metasoma form the largest complex of muscles in the metasoma, all functioning in the retraction of the tergal or sternal plates over one another. The retraction of these individual plates results in the decreased length or contraction of the metasoma. The median dorsal longitudinal muscle (7, 15) and the lateral dorsal longitudinal muscles (8, 16) serve as tergal retractors, whereas the ventral longitudinal muscles (12, 20) and the lateral ventral muscles (13, 21) serve as retractors of the sternal plates.

The extensors of the abdomen consist of the reversed external dorsal muscles (9, 17) and the reversed external ventral muscles (14, 22). When contracted, these muscles reduce the overlap between the tergal and sternal plates respectively. The reduction in the overlap between plates results in the extension of the abdomen.

The dilators of the metasoma consist of but a single muscle in each segment. Upon contraction, the accessory dorsoventral muscle (11, 19) reduces the overlap of the tergum over the sternum, thus dilating or increasing the breadth of the segment.

The compressors of the metasoma consist of but a single muscle in segments III and IV, the anterior dorsoventral muscle (10, 18). When this muscle is contracted, the overlap between the tergal and sternal plates is increased, thus compressing the metasoma.

The musculature of segment II (Fig. 4) is very similar to that of segments III and IV. One of the most outstanding differences is the enlargement of the dorsoventral muscle (4). This muscle differs in its origin and insertion from the dorsoventral muscles of other segments but it is believed to be homologous with other dorsoventral muscles. The lateral dorsal (2) and lateral ventral (6) muscles are both divided two-branched muscles, while in segments III and IV these muscles are undivided. The presence of two or more branches in any muscle having a common insertion presumably produces a tempering effect upon the movement brought about by the contraction of the muscle, as well as greater versatility of movement. The origins of the two branches of the lateral dorsal longitudinal muscle (2) are quite remote; one branch, 2a, has its origin on the anterior inflected wall of the tergum; and the other, 2b, originates on the dorso-lateral wall of the tergum. The simultaneous contraction of both these branches results in a more even movement than would the contraction of a single muscle.

The musculature of segment V (Fig. 4) is essentially the same as that of segments III and IV. The only difference is the addition of another compressor of the metasoma, the posterior dorsoventral muscle (27).

The pattern of musculature of segments VI and VII (Fig. 5) is essentially the same. The lateral dorsal longitudinal muscles (33 and 40) are three-branched muscles in both segments. The anterior dorsoventral muscles are lacking in both segments, but the posterior dorsoventral muscles (35 and 42) are retained. Except

for these modifications the dorsal musculature of segments VI and VII is the same as found in segments III and IV. In the ventral complex of muscles the lateral ventral muscle is no longer retained in segments VI and VII. In addition to the loss of this muscle in segment VII, the reversed external ventral muscle is also missing. This leaves the ventral longitudinal muscle (44) as the only evident ventral muscle in segment VII. The loss of the ventral muscles in segment VII is perhaps coincident with the marked reduction in the size of sternum VIII. One might postulate that the musculature of certain of the Anthidiini, in which the eighth sternum resembles the sternum of preceding segments, may not be so greatly reduced.

The musculature of segment VIII (Figs. 5 and 6) is reduced to three pairs of muscles; the median dorsal longitudinal muscle (45), the lateral dorsal longitudinal muscle (46), and the ventral longitudinal muscle (47). These function in a manner similar to their homologs in preceding segments.

The three pairs of muscles associated with segment IX (Figs. 5 and 6) are directly concerned with the mechanism of extrusion of the genital bulb from the body during coition. In the past the mechanism of the extrusion of the genital bulb in the bees has not been thoroughly understood. As a result, several possible explanations for the extrusion for the male genitalia have arisen. Rohwer (1915) has recorded the mating behavior of several sawflies. Of *Xiphydria maculata* Say, he states that "during copulation . . . there is a contraction and expansion of the muscles of the stipes [gonoforceps] so there is a strong push and pull motion." Peck (1937) has summarized the literature relative to the mating behavior of the ichneumonids. Peck has shown that the distal portion of the gonoforceps in the ichneumonids grips the lateral portions of the subgenital plate of the female during copulation, and that the "function of the volsellae is apparently to seize the conjunctival membrane, keeping it taut so that the aedeagus can be inserted into the female gonopore and be retained there." The literature relative to copulation among the bees is very fragmentary, and deals primarily with the premating behavior of the male. The author knows no record of the mechanism of copulation among the megachilid bees.

The mechanism of phallic extrusion in the drone honeybee has been demonstrated by Shafer (1917) to be brought about by first filling the air sacs and trachea with air, followed by a contraction of the abdomen. As a result, "the confined air in the vesicles of the tracheal system becomes compressed; the blood in the body cavity, however, moves freely to the area of least resistance—to the base of the penis. In that moment the crumpled tubular penis wall, next the genital slit, is pushed through the slit and swells out behind—expanded with blood." Further expansion is accomplished by a mixture of blood and air being forced into the penis until it is freely extended. To further substantiate this explanation, Snodgrass (1924) has shown that there are no muscles intimately associated with the genitalia which could possibly account for the eversion of the phallus of the honeybee.

Since the honeybee was the first among the bees to be understood anatomically, many of the studies on the morphology of the bees have either accepted the explanation of phallus eversion as found in the honeybee or have ignored the functional aspects of genitalia eversion. The genitalia of *Apis* are largely membranous, being characterized by a marked reduction in sclerotic structures. As a result, the analogy of copulatory procedure cannot be made with any assurance of accuracy between the honeybee and any other group of bees.

Perhaps following this method of reasoning or because of his sole reliance

upon boiled specimens Beck (1933) in his work on morphology of the male genitalia of the bees has reached the conclusion that "there are no muscles directly attached to the armature from the 9th sternite or tergite, the only connecting tissue is the membrane. The extrusion of the genital armature at the time of copulation is accomplished by means of musculature contraction of the body walls, the body fluids thus compressed forcing the armature from the body."

The fact that the genital bulb may be protruded by manipulation by applying pressure upon the abdomen with the finger tips, is apparently not significant. By analogy, a distended balloon will break when additional pressure applied upon the balloon exceeds the elastic limit. Likewise, when pressure is applied to the abdomen of a bee by means of the finger tips, it will "give" at its weakest point to release the pressure when the breaking limit has been attained. Since the weakest point in the body is undoubtedly that of the orifice through which the genitalia are extruded, the genitalia will be everted—regardless of the presence or absence of muscles. The assumption that the genitalia in nature are extruded solely by the action of blood pressure, as is apparently the case in *Apis*, is not entirely tenable in the greater majority of bees. A definite pattern of musculature accounts not only for the protraction and retraction of the genital bulb, but also for the retraction of the membranous penis in the Megachilidae.

Since there are no records in the literature of the mating behavior of the megachilid bees the following discussion of the copulatory mechanism must be based entirely upon the musculature of the male genitalia and associated sterna. To determine the probable function of the muscles of the genitalia three methods have been employed in both living and preserved specimens: deduction, micro-manipulation, and the comparison of the musculature of everted and noneverted genitalia.

It is significant to note that in the mechanism for the extrusion of the external genitalia the musculature of segments VI and VII is not only characterized by a full complement of muscles but also by the three-branched lateral dorsal longitudinal muscles (33 and 40). When contracted, this set of six muscles together with the median dorsal longitudinal muscles (32 and 39) accounts for the contraction of the seventh and eighth metasomal terga (Fig. 5). Because of the small size of the ninth tergum, the contraction of the eight muscles that serve as retractors of the metasomal terga VII and VIII also retracts the ninth metasomal tergum to a slight extent. Further retraction of the ninth metasomal tergum is produced by the contraction of the only tergal muscle in segment IX, the median dorsal longitudinal muscle (45). As a result, the ninth tergum is uplifted leaving a caudal opening for the genital capsule to pass through to the outside of the body. The numerous branches of 33 and 40 allow for an increase in the possible movements required for the opening of the orifice through which the genitalia exit. In like manner, the contraction of the ventral longitudinal muscles (37 and 44) pull the sterna forward, opening the orifice ventrally. The two branches of the large and powerful accessory dorsoventral muscle (36a and 36b) of segment VI also aid in this function. By their contraction, the basal portion of the sternum is pulled upward, thereby depressing the caudal portion of the segment.

In a sense, muscle 47 functions as a reversed muscle because of its relative position, but it is a homolog of the ventral longitudinal muscles of other segments. After the exit for the external genital bulb is open, the contraction of this muscle protrudes the capsule outside the body. Because of its close association with the genital capsule the ninth sternum is also protruded from the body.

Upon extrusion from the body, the genital capsule is directed anterad. A continuous membrane is attached around the base of the genital foramen and is connected with the ninth sternum and tergum. This membranous tube allows for the passage of the genital ducts from the metasoma into the genital capsule and for the free flow of body fluids. The dorsal portion of the membrane is proportionately much longer than its ventral counterpart. The extremely large protractor of the genital capsule (50), when contracted, further increases the forward movement of the genital capsule. The basic factors that contribute to the forward position of the genital capsule upon extrusion from the metasoma include the proportionately much longer membrane dorsally connecting the genital capsule, the intimate association of the genital capsule with the ninth sternum, and the absence of any dorsal muscles connecting the genital capsule with the terga.

Eleven paired muscles are found within the genital capsule of *Megachile fortis*. Significantly, ten pairs of these muscles function in the movement of the aedeagus and penis. The muscles that function in the movement of the aedeagus may be classified as levators, compressors, retractors, or depressors. It is difficult to assign arbitrarily any one function to a particular muscle because of the various planes in which the origins and insertions of the various muscles of the aedeagus may be found and the possible effect which the action of any other muscle or set of muscles may have upon the net effect of another. The muscles have been named with what is presumed to be their primary function, but the reader must keep in mind that these various functions may be materially altered by the effect of other muscles. The supposed effect of many of these muscles is outlined in the text along with the primary result of the contraction of any individual muscle. One further complicating factor in the terminology of the muscles of the genital capsule is the fact that the genital bulb is actually upside-down when in a copulatory position. Thus, a depressor of aedeagus, if it were in its morphologically normal position (Figs. 6, 7, and 8) as outlined in the text, would actually function as a levator because of this reversed position *in situ*.

Three muscles serve primarily as levators (51, 57, and 58) in that the primary effect of their contraction is that of elevation (actually, depression) of the penis valves; however, considering the length of the posterior levator of aedeagus (58), and its origin on the dorsolateral wall of the gonocoxite, and its insertion on the lower arm of the aedeagal apodeme it must also function, to a certain extent, as a compressor of the aedeagus. This is particularly true if the muscle is contracted by itself for the net result is an inward and upward motion at the same time. Thus, by alternate contractions of 58 and the combined action of 51 and 57 there is a considerable twisting motion of the penis valves.

Two other muscles also play an important role in the compression of the aedeagus. The compressor of the aedeagus (52) is a particularly large and powerful muscle which, by its contraction, is capable of pulling the two opposing penis valves together (Figs. 8 and 9). The accessory compressor of the aedeagus (56) also functions in the same manner (Fig. 7). A marked difference in the total effect of the two muscles may be noted. The direction of pull of 56 is from the anterior end on the outer side of the penis valve, tending to pull mesally only the apical ends of the penis valves. The pull of 52, however, is from the inner side of the penis valve. Because their insertions extend along the length of the inner edge of the penis valves, the contractions of these two muscles pulls the two penis valves inwardly toward one another, rather than tipping only the apical end of the penis valves mesally.

Two paired muscles that function primarily as depressors (actually, levators) include 54 and 61. Although 54 is a very short and small muscle (Fig. 8), its origin is ventrad of the penis valve and it tends to draw the entire penis valve ventrally upon contraction, thus lowering the position of the penis valve. The origin of 61, on the other hand, is dorsad of the penis valve (Figs. 7 and 8) and its contraction tends to depress only the caudal end of the penis valve rather than the entire structure. Likewise, the action of 61 when functioning alone has some dilating effect by pulling the penis valves apart, since its origin is mesad and dorsad on the roof of the gonocoxite of its insertion on the aedeagal apodeme.

The combined action of these various muscles account for the extrusion of the genital capsule preparatory for copulation. It can only be speculated how the various external genitalic structures function during copulation. Certainly, the entire aedeagus including the penis and penis valves, because of their fused nature in this group of bees must function as the intromittent organ. The numerous possible movements including levation, depression, compression, and the twisting action of the penis valves must surely aid in gaining entrance into the female. Two possible functions for the gonoforceps include clasping the female and holding taut the genital membrane of the female.

The external male genitalia are presumed not to be lost after mating, as is the case in the honeybee, but rather are withdrawn into the metasoma. Several muscles aid in the retraction of the genital capsule. The extremely elongate retractor of the penis (59) pulls the membranous penis back into place, and because of the fused nature of the penis and penis valves must also function as a retractor of the aedeagus. The retractor of the aedeagus (55) is a short but robust muscle originating on the gonobase which, when contracted, pulls the entire penis valve anteriorly. The accessory retractor of the aedeagus (53) also functions in the retraction of the aedeagus. However, because of its position laterad of the penis valve it also pulls the apices of the penis valves apart. In this respect it functions antagonistically to muscle 58, and would likewise complement the twisting action of the penis valves previously described by muscles 51, 57, and 58.

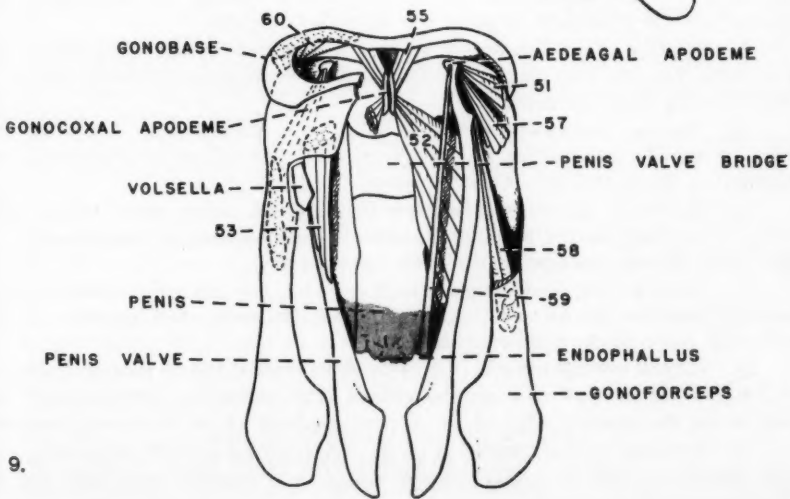
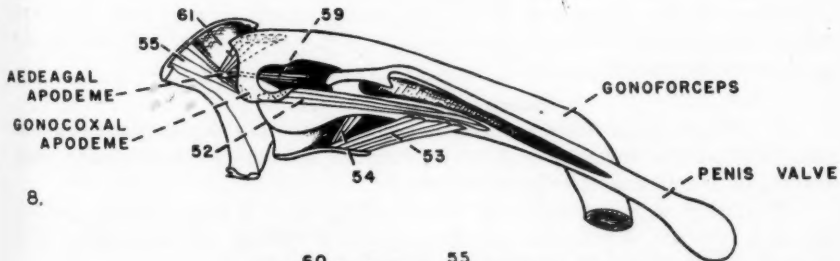
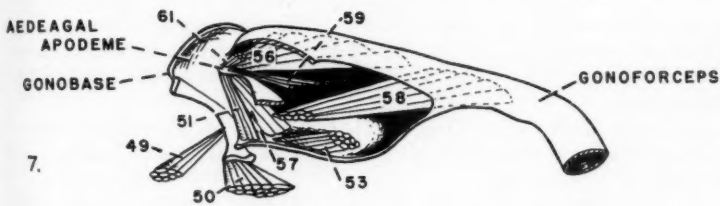
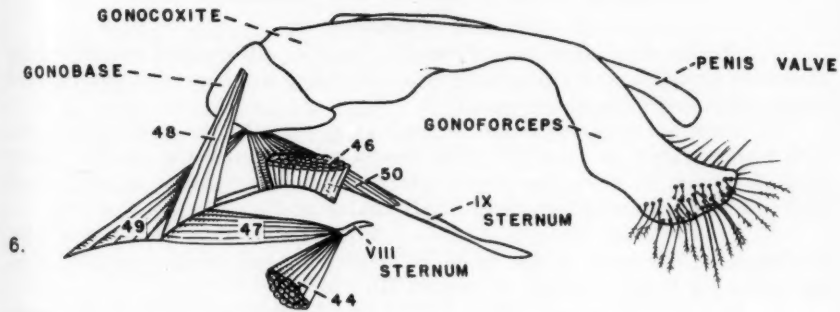
The simultaneous contraction of 48, 49, and 50 would draw the genital capsule back into its normal position in close apposition to the ninth sternum. A muscle (46) that functions as a retractor of the ninth sternum, but is believed to be a homolog of the posterior dorsoventral muscles of other segments, pulls the ninth sternum, accompanied by the genital capsule, back into the metasoma. The only remaining function to complete the process is that of closing the exit for the extrusion of the genital capsule. This is accomplished by the contraction of the compressors of the metasoma (10, 18, 26, 27, 35, and 42). The absence of any compressors of the metasoma in the eighth segment would account for the incomplete closure of the genital opening, which is frequently observed in this group of bees.

Fig. 6. Musculature of the eighth and ninth sterna of *Megachile fortis* Cresson.

Fig. 7. Parasagittal section through the base of the gonocoxite of the male genitalia illustrating the musculature of *Megachile fortis* Cresson.

Fig. 8. Sagittal section through the external male genitalia illustrating the musculature of *Megachile fortis* Cresson.

Fig. 9. Ventral view of the external male genitalia with a portion of the right side and membranous portions removed to illustrate the musculature of *Megachile fortis* Cresson.



**Annotated List of Metasomal and Genital Muscles****Muscles of Segment II**

1. *Median dorsal longitudinal muscle* (Fig. 4). An elongate muscle arising anteriorly on the frontal wall of tergum II, extending dorsolaterally, and inserted on the antecostal ridge of tergum III.
2. *Lateral dorsal longitudinal muscle* (Fig. 4). A two-branched muscle. The larger branch, 2a, is a powerful muscle arising anteriorly on the frontal wall of tergum II, extending caudoventrally, and 2b, originates on the lateral wall of tergum II and inserts immediately laterad of 2a.
3. *External dorsal muscle* (Fig. 4). A reversed muscle, arising as a wide band beneath the apical tergal flange of tergum II, and inserted on the outer surface of the tergal apodeme of tergum III.
4. *Dorsoventral muscle* (Fig. 4). A relatively short but very robust muscle originating on the frontal wall of the tergum, extending caudomesally to its insertion on the sternal wall of the same segment. The homologies of this muscle could not definitely be determined, but the origin and insertion of this muscle would seem to suggest its homologies with the anterior dorsoventral muscles of the following segments.
5. *Ventral longitudinal muscle* (Fig. 4). An elongate muscle arising anteriorly on the inflected wall of sternum II, extending caudomesally, and inserted on the antecostal ridge of sternum III.
6. *Lateral ventral muscle* (Fig. 4). A large powerful muscle composed of two branches: 6a, originating ventrally on the sternum; 6b, the much smaller branch consisting of but new fibers, originating laterad of 6a. Both branches extend dorsolaterally and insert commonly on the anterior margin of the sternal apodeme of sternum III.

**Muscles of Segment III**

7. *Median dorsal longitudinal muscle* (Fig. 4). An elongate muscle arising anteriorly on the inflected wall of the tergum, extending caudomesally, and inserted on the antecostal ridge of tergum IV.
8. *Lateral dorsal longitudinal muscle* (Fig. 4). A large muscle arising anteriorly on the lateral wall of the tergum, extending caudoventrally, and inserted on the antecostal ridge of the following tergum.
9. *External dorsal muscle* (Fig. 4). A reversed muscle, originating as a wide band beneath the apical tergal flange, and inserting on the outer surface of the following tergal apodeme.
10. *Anterior dorsoventral muscle* (Fig. 4). A very short but wide thin sheet of muscle, originating on the tergal wall, extending ventromesally, and inserted on the lateral rim of the sternum.
11. *Accessory dorsoventral muscle* (Fig. 4). A rather short muscle originating posteriorly on the tergal wall, extending cephalomesally, and inserted on the lateral sternal apodeme of the same segment.
12. *Ventral longitudinal muscle* (Fig. 4). An elongate muscle arising anteriorly on the sternal wall, extending cephalomesally, and inserted on the antecostal ridge of the following sternum.
13. *Lateral ventral muscle* (Fig. 4). A delicate elongate muscle consisting of but few fibres that arise on the sternal wall, extending dorsolaterally and inserted on the anterior edge of the sternal apodeme of the following segment.
14. *External ventral muscle* (Fig. 4). A reversed muscle originating as a wide sheath beneath the apical sternal flange, and inserted anteriorly on the following sternal apodeme.

**Muscles of Segment IV**

15. *Median dorsal longitudinal muscle* (Fig. 4). Similar to 7.
16. *Lateral dorsal longitudinal muscle* (Fig. 4). Similar to 8.
17. *External dorsal muscle* (Fig. 4). Similar to 9.
18. *Anterior dorsoventral muscle* (Fig. 4). Similar to 10.
19. *Accessory dorsoventral muscle* (Fig. 4). Similar to 11.
20. *Ventral longitudinal muscle* (Fig. 4). Similar to 12.
21. *Lateral ventral muscle* (Fig. 4). Similar to 13.
22. *External ventral muscle* (Fig. 4). Similar to 14.

**Muscles of Segment V**

23. *Median dorsal longitudinal muscle* (Fig. 4). Similar to 7.
24. *Lateral dorsal longitudinal muscle* (Fig. 4). Similar to 8.
25. *External dorsal muscle* (Fig. 4). Similar to 9.
26. *Anterior dorsoventral muscle* (Fig. 4). Similar to 10.
27. *Posterior dorsoventral muscle* (Fig. 4). A slender elongate muscle arising on the tergum, extending caudoventrally, and inserted on the rim of the sternum. This muscle is usually more or less hidden by the much larger muscle 24.
28. *Accessory dorsoventral muscle* (Fig. 4). Similar to 11.
29. *Ventral longitudinal muscle* (Fig. 4). Similar to 12.
30. *Lateral ventral muscle* (Fig. 4). Similar to 13, but more robust.
31. *External ventral muscle* (Fig. 4). Similar to 14.

**Muscles of Segment VI**

32. *Median dorsal longitudinal muscle* (Fig. 5). Similar to 7.
33. *Lateral dorsal longitudinal muscle* (Fig. 5). A muscle consisting of three parts; 33*a* arises on the mid-lateral wall of the tergum and inserts on the antecostal ridge of tergum VII; 33*b*, a much smaller muscle, arises posterior to 33*a* and inserts above the insertion of 33*a*; 33*c*, a very small muscle consisting of but few fibres, arises posterior to 33*b* and inserts above the insertion of 33*b*.
34. *External dorsal muscle* (Fig. 5). Similar to 9.
35. *Posterior dorsoventral muscle* (Fig. 5). Similar to 27, except that it is inserted by means of a short tendon.
36. *Accessory dorsoventral muscle* (Fig. 5). In most specimens similar to 11. A few specimens have been noted in which the muscle has become divided; the major portion of the muscle being inserted on the posterior margin of the sternal apodeme, and a few fibres extending over the apodeme and inserted internally on the anterior margin of the sternal apodeme.
37. *Ventral longitudinal muscle* (Fig. 5). Similar to 12, though less robust.
38. *External ventral muscle* (Fig. 5). Similar to 14.

**Muscles of Segment VII**

39. *Median dorsal longitudinal muscle* (Fig. 5). Similar to 7.
40. *Lateral dorsal longitudinal muscle* (Fig. 5). Similar to 33.
41. *External dorsal muscle* (Fig. 5). Similar to 9.
42. *Posterior dorsoventral muscle* (Fig. 5). Similar to 35, though shorter and more robust, and is inserted by a much longer tendon.
43. *Accessory dorsoventral muscle* (Fig. 5). Similar to 11.
44. *Ventral longitudinal muscle* (Figs. 5 and 6). Similar to 12.

**Muscles of Segments VIII and IX**

45. *Median dorsal longitudinal muscle* (Fig. 5). Similar to 7.
46. *Posterior dorsoventral muscle* (Figs. 5 and 6). Similar to 27, though a much stouter muscle.

47. *Ventral longitudinal muscle* (Figs. 5 and 6). A stout muscle originating posteriorly on the much reduced sternum VIII, extending mesally, and inserting on the spiculum of sternum IX.

48. *Levator of the genital bulb* (Figs. 5 and 6). An elongate muscle, originating on the dorsal surface of the spiculum caudad of muscle 47, extending dorsally, and inserting on the dorsolateral surface of the gonobase.

49. *Retractor of the genital bulb* (Figs. 5 and 6). Originating on the dorsal surface of the spiculum, extending caudolaterally, and inserting ventrally on the antecostal ridge of the gonobase.

50. *Protractor of the genital capsule* (Figs. 5 and 6). An extremely large wide band of muscle originating posteriorly on sternum IX, extending antero-mesally, and inserted on the antecostal ridge of the gonobase.

#### Muscles of the Genitalia

51. *Levator of the aedeagus* (Figs. 7 and 9). A large powerful muscle originating ventrally on the gonocoxites, extending dorsomesally, and inserting on the outer surface of the dorsal arm of the aedeagal apodeme.

52. *Compressor of the aedeagus* (Figs. 8 and 9). A large fan-shaped muscle originating anteriorly on the gonocoxal apodeme, extending posterolaterally, and inserting along the inner lateral surface of the penis valve.

53. *Accessory retractor of the aedeagus* (Figs. 7, 8, and 9). A powerful muscle originating ventrally on the gonocoxite, extending caudally to its insertion below that of muscle 52 on the arm of the penis valve.

54. *Depressor of the aedeagus* (Fig. 8). A very small short muscle originating ventrally on the gonocoxite laterad of muscle 53, extending dorsally, and inserting on the ventral surface of the arm of the penis valve.

55. *Retractor of the aedeagus* (Figs. 8 and 9). A short robust muscle originating anteriorly on the dorsal median ridge of the gonobase, and inserting posteriorly on the gonocoxal apodeme.

56. *Accessory compressor of the aedeagus* (Fig. 7). A very large robust muscle originating on the dorsolateral wall of the gonocoxite, extending mesally, and inserting on the dorsal surface of the arm of the penis valve apodeme.

57. *Accessory levator of the aedeagus* (Figs. 7 and 9). A robust muscle arising on the lateral ventral wall of the gonocoxite, extending mesally, and inserting posterior to the insertion of muscle 51 on the aedeagal apodeme.

58. *Posterior levator of the aedeagus* (Figs. 7 and 9). A large muscle originating on the dorsolateral wall of the gonocoxite immediately posterior to the origin of muscle 56, extending mesoventrally, and inserting on the ventral arm of the aedeagal apodeme.

59. *Retractor of the penis* (Figs. 2, 3, 7, 8, and 9). An extremely long muscle composed of but a few fibres which originates on the internal face of the aedeagal apodeme immediately ventrad of the insertion of muscle 61, extending caudally, and inserting on the membranous fold of the penis at the juncture of the endophallus.

60. *Levator of the gonocoxopodites* (Fig. 9). A very large robust muscle originating on the anterior wall of the gonobase, extending posterolaterally, and inserting on the antecostal ridge of the gonocoxite.

61. *Dorsal depressor of the aedeagus* (Figs. 7 and 8). A short muscle originating dorsally on the roof of the gonocoxite, extending ventrally, and inserting on the inner lateral surface of the aedeagal apodeme.

### Summary

The morphology of the male metasoma and genitalia of *Megachile (Phaenoserus) fortis* Cresson was studied. This included the muscular system and the functional aspects of the skeleto-muscular mechanism for the movements of the metasoma, the extrusion and retraction of the male genital capsule, and an explanation of the possible movements of the genital capsule during copulation.

The metasoma in the Megachilidae consists of segments II through IX of the definitive abdomen. Antecosta are conspicuous structures on the anterior margins of each of the sternal and tergal plates. Acrotergites are well developed, but acrosternites are lacking. The tergal graduli are conspicuous structures in the Megachilidae. The presence of four muscles that are homologous to those found in other metasomal segments confirms the identity of the two small sclerites situated in the intersegmental membrane between the seventh and ninth sterna as remnants of the eighth sternum in the Megachilidae.

The internal morphology of the male genital system of three representative megachilid bees was studied. The internal organs of these bees consisted of the paired testes, which were enclosed in a common peritoneal sheath, the vasa deferentia, the seminal vesicles, and the median ejaculatory duct, which terminates in the gonopore.

The muscular system of the metasoma and external genitalia of *Megachile fortis* Cress. consisted of 136 muscles. The muscles of the metasoma have been classified into four functional categories: dilators, extensors, contractors, and compressors. It has been shown that the extrusion of the genital bulb from the body at the time of copulation is accomplished entirely by muscles; and not by blood pressure as previously been thought to be so.

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## Recovery of Insect Fragments from the Waste and Juice of Processed Tomatoes<sup>1</sup>

By L. A. MILLER<sup>2</sup>

Entomology Laboratory, Chatham, Ontario

The corn earworm, *Heliothis zea* (Boddie), is seldom a pest of economic importance in tomatoes in southern Ontario. However, in 1953 the harvest of tomatoes for processing was prematurely terminated because of the presence of this pest in the ripe fruits. In that year almost all the fields in Kent and Essex counties, involving approximately 12,000 acres, were infested, the infestations being as high as 11 per cent in individual fields. The situation was aggravated because excellent-appearing fruits with no visible larval entry holes often contained earworms. This condition occurred when the newly hatched larvae had burrowed immediately into the fruits and there completed their larval development. The entry holes soon healed, leaving small scars that were almost impossible to detect, particularly on a busy production line.

This is a report on a study, conducted in 1954, on where and in what condition known insect contaminants were found and whether unknown contaminants were present in the waste and juice of tomatoes after regular commercial processing.

### Methods

Five lots each of 50 whole tomatoes were removed from the processing line of a canning factory after completion of washing. The tomatoes were cut open to ensure that corn earworm larvae were not present. One, 3, 5, 25, and 50 nearly mature corn earworm larvae were distributed within the individual lots to simulate 2, 6, 10, 50, and 100 per cent infestations respectively. The lots were then individually processed in the factory by cooking the tomatoes and expressing the juice through a sieve containing approximately 240 perforations per square inch, each 0.02 in. in diameter. The juice was canned and the waste frozen in waxed cardboard containers for future examination.

In addition, one lot of 250 tomatoes containing 25 earworms (10 per cent infestation) was processed to determine what fragments of the earworm could be recovered when larger quantities of waste and juice were involved.

The juice from each level of infestation was centrifuged in 50-ml. portions for 4 min. The supernatant liquid was drawn off and filtered and the filter paper examined under 27X magnification for insect fragments.

Separation of the insect fragments from the pulp that remained after the juice was centrifuged was carried out by the method of the Association of Official Agricultural Chemists (1950, p. 725) (A.O.A.C. examination). This method involves the addition of castor oil and warm water to the pulp, occasional stirring, and trapping off the oil and water layers into a beaker. These trappings, which contained earworm fragments and other contaminants, were then filtered and the papers examined microscopically.

The waste was initially examined without magnification (gross examination) and the macro fragments removed. The waste was then divided into 100-gm. lots and subjected to the official method for further separation of contaminants.

### Results and Discussion

No insect fragments were found in the supernatant liquid of the tomato juice.

<sup>1</sup>Contribution No. 3478, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Associate Entomologist.

TABLE I

Numbers of corn earworm fragments and other contaminants taken in gross and official examinations of the waste of lots of 50 tomatoes each with a known earworm infestation

Contaminant	Gross examination					A.O.A.C. examination				
	Percentage infestation					Percentage infestation				
	2	6	10	50	100	2	6	10	50	100
<i>Earworm Fragments</i>										
Head capsule detached, and entire...	0	0	0	1	7	0	0	0	0	1
Head capsule with entire skin.....	0	0	4	10	20	0	0	0	0	0
Head capsule with part of skin.....	1	2	0	13	21	0	0	1	1	0
Total.....	1	2	4	24	48	0	0	1	1	1
Large skin.....	0	2	9	15	20	1	0	0	0	4
Small skin.....	0	0	0	0	0	0	27	N*	N	N
Thoracic shield.....	0	0	0	0	0	0	0	0	0	2
Mouth parts.....	0	0	0	0	0	0	3	0	2	0
Thoracic leg, entire.....	0	0	0	0	0	0	0	0	0	6
Thoracic leg, parts.....	0	0	0	0	0	0	4	4	3	5
Abdominal leg, parts.....	0	0	0	0	0	0	2	0	1	0
Chitin.....	0	0	0	0	0	0	1	3	4	12
Gut or trachea.....	0	0	0	0	0	0	6	39	N*	N
<i>Other Contaminants</i>										
Vinegar fly adults.....	0	0	0	0	0	0	0	1	0	4
Vinegar fly wings.....	0	0	0	0	0	0	0	0	0	1
Aphids.....	0	0	0	0	0	0	0	2	0	0

\*More than 50.

The gross examination and the official method of separation removed a great many fragments. For example, out of 109 earworms used in the experiment, 107 head capsules were recovered from the waste (Tables I and II). The missing head capsules were not recovered in the pulp (Table III), and it is assumed that they remained in the waste or were lost in the canning factory, where a certain amount of waste from each operation is inevitable. It is possible that, under pressure, fragments became so firmly embedded in the waste as to make their recovery almost impossible by the official method of separation. The recovery of head capsules was not adversely affected by the increased number of tomatoes in the second experiment (Table II).

A sieve containing approximately 240 perforations per square inch, each 0.02 in. in diameter, removes macro fragments but numerous micro fragments such as skin, gut, and trachea enter the finished product (Table III). Most of the fragments, irrespective of size, were trapped in the folds of tomato skins and retained in the waste. The only earworm fragments recovered from the juice of tomatoes with a 2 per cent infestation were a part of one abdominal leg and one seta. Unless extraordinary conditions prevail, field infestations greater than 2 per cent would not be expected in southern Ontario. It is likely that undetected, light infestations occur frequently and that a small amount of adulteration is caused by the earworm. As all the juice in these experiments was carefully examined, the chances are extremely remote that the commercial sampling procedure would detect insect fragments in juice made from tomatoes with a 2 per cent infestation of the earworm.

TABLE II

Numbers of corn earworm fragments and other contaminants taken in gross and official examinations of the waste and juice of 250 tomatoes containing 25 earworms

Contaminant	Waste		Juice
	Gross examination	A.O.A.C. examination	A.O.A.C. examination
<i>Earworm Fragments</i>			
Head capsule, detached and entire.....	1	1	0
Head capsule with entire skin.....	13	0	0
Head capsule with part of skin.....	10	0	0
Total.....	24	1	0
Large skin.....	13	10	0
Small skin.....	0	N*	N
Setae.....	0	0	4
Chitin.....	0	0	2
Gut or trachea.....	0	N	N
<i>Other Contaminants</i>			
Vinegar fly eggs.....	0	0	9
Mites**.....	0	0	2

\*More than 50.

\*\**Tetranychus bimaculatus* Harvey.

The occurrence of contaminants not purposely added to the tomatoes is remarkable. Recent investigations by Fields *et al.* (1955) have shown that the official method is not entirely satisfactory for separation of the eggs of the vinegar fly *Drosophila melanogaster* Mg. from tomato juice. Hence the number of eggs of this species in the juice examined in these experiments was probably considerably more than the 21 taken (Tables II and III).

It is almost certain that tomato products processed in southern Ontario in some years are contaminated to some extent with the eggs, maggots, or remains of vinegar flies and with aphids, thrips, and mites. Here again, it is unlikely that the commercial sampling procedure would detect the contaminants. However, that such an adulteration does occur is cause for some concern and every effort should be made to reduce the source of contamination to a minimum.

The control of vinegar flies in the field and in the factory poses a difficult problem for quality-conscious processors. The flies appear in incredible numbers during the harvest period. Michelbacher *et al.* (1953), in California, have associated fly abundance in tomato fields with the amount of crushed or culled fruit found in the hamper rows or portions of the field where equipment has run over the vines. Hence any carelessness in picking or handling that would result in discarded, broken fruits would contribute to infestations. The flies are particularly abundant around hampers of tomatoes awaiting processing at the factory. It is not uncommon to observe juice on the sides of hampers that have been filled too full with overripe tomatoes. The flies are attracted to and lay eggs in these areas and also in growth cracks of the fruits or where the skin has been broken by other causes. For this reason it is imperative that the time between picking and processing be kept to a minimum; otherwise a double adulteration results: a maggot and its empty egg shell. Desrosier *et al.* (1955), in Indiana, have recommended that tomatoes held overnight before processing should be treated with 0.05 per cent pyrethrum spray. They further suggest sound sanitary practices

TABLE III

Numbers of corn earworm fragments and other contaminants taken in gross and official examinations of the juice of lots of 50 tomatoes each with a known earworm infestation

Contaminant	Per cent Infestation				
	2	6	10	50	100
<i>Earworm Fragments</i>					
Thoracic leg, parts.....	0	1	0	3	6
Abdominal leg, parts.....	1	0	1	1	3
Small skin.....	0	27	38	48	N
Setae.....	1	1	0	4	12
Chitin.....	0	1	0	0	4
Gut or trachea.....	0	33	48	N	N
<i>Other Contaminants</i>					
Vinegar fly, adult leg parts.....	1	0	1	1	2
Vinegar fly, adult head.....	0	0	0	0	1
Vinegar fly wings.....	0	0	0	0	2
Vinegar fly eggs.....	3	0	2	0	7
Thrips.....	0	0	2	0	0
Aphids.....	0	0	0	2	0

such as keeping the plant and premises thoroughly clean and not allowing any tomato material to accumulate and ferment. They have also found that the number of flies can be reduced considerably by spraying the outside of the plant with an insecticide such as malathion and by using a knockdown spray of 0.05 per cent pyrethrum daily on the inside when the plant is not in operation. To add to these suggestions, it is recommended that growers be cautioned against filling beyond the level of the hamper and that particular care be taken to ensure that the fruits do not become overripe. The hampers should be thoroughly washed after use to remove any tomato material.

#### Summary

Commercial processing of tomatoes into juice removed all macro fragments of nearly mature corn earworms added to simulate field infestations. All macro fragments and most of the micro fragments, consisting mainly of skin, gut, and trachea, were found in the tomato waste. Numerous micro fragments were recovered from the tomato juice. Other contaminants taken in the experiment were aphids, thrips, mites, and adults, heads, leg parts, wings and eggs of the vinegar fly *Drosophila melanogaster* Mg.

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## Studies of Predators of the Balsam Woolly Aphid, *Adelges piceae* (Ratz.) (Homoptera: Adelgidae)

### II. An Annotated List of the Predators Associated with the Balsam Woolly Aphid in Eastern Canada<sup>1,2</sup>

By N. R. BROWN<sup>3</sup> AND R. C. CLARK<sup>4</sup>

The present paper is the second of a series arising from a continuing study of the balsam woolly aphid, *Adelges piceae* (Ratz.), and its biological control. The history of this introduced insect has been described (Balch, 1952). During the course of our studies a number of records of species associated with *A. piceae* have been obtained.

There are numerous types of associations between insect species. Odum (1953) recognizes eight: neutralism, competition, mutualism, proto-cooperation, commensalism, amensalism, parasitism, and predation. In this case we have found no examples of mutualism, proto-cooperation, amensalism or parasitism. Neutralism undoubtedly occurs, many species of insects having been observed to visit briefly the trunks of infested balsam fir (*Abies balsamea* (L.) Mill.). A form of commensalism may possibly occur in the case of numerous species of Collembola and Psocoptera found on the bark of balsam fir, which may benefit from microclimatic effects caused by the presence of heavy infestations, but the association may be competitive for space. Atwood (1933) mentions an ant, *Myrmica scabrinodis* Nyl., feeding on the anal secretions of the adelgids.

By far the most common association is predation and the following discusses the various species known to be predacious, probably predacious, or possibly predacious.

Numerous brief references to the predators that feed on *A. piceae* have appeared in the literature but a complete list of these and other associated insects has not hitherto been published. The present paper is a compilation of the notations on predators from various publications, notably those of Balch, and also from unpublished reports of other officers of the Department of Agriculture. The identifications were obtained through the assistance of the Systematic Entomology and Biological Control Unit, Entomology Division, Department of Agriculture, Ottawa. All observations not made by the writers are acknowledged individually.

It is not proposed in the present listing to discuss in detail the importance of all species in the natural control complex of the prey but reference will be made to the biology of the more important species and their feeding habits in relation to the adelgid. Detailed discussion of control value will be the subject of future papers in this series, particularly in the case of introduced species.

Twelve species of predators have been introduced into Eastern Canada through the cooperation of the Entomology Laboratory (formerly the Dominion Parasite Laboratory), Belleville, Ontario and the Commonwealth Institute of Biological Control. Liberations were made from 1933 to 1937, in 1941, and from 1951 to 1955. No recoveries of the following species have been made.

*Hemerobius nitidulus* Fabr. (Neuroptera: Hemerobiidae)

*Hemerobius stigma* Sch. (Neuroptera: Hemerobiidae)

<sup>1</sup>Contribution No. 311, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Joint Project of Forest Biology Laboratory, Science Service, Department of Agriculture, Fredericton, N.B. and Department of Lands and Mines of New Brunswick, financed in part by a grant from the Provincial Department.

<sup>3</sup>Professor of Forest Entomology, Faculty of Forestry, University of New Brunswick, Fredericton, N.B.

<sup>4</sup>Research Officer, Forest Biology Laboratory, Fredericton, N.B.

*Exochomus quadripustulatus* L. (Coleoptera: Coccinellidae)

*Aphidoletes thompsoni* Möhn (Diptera: Cecidomyiidae)

*Neocnemodon* spp. (prob. *latitarsis* Egg. and *pubescens* D. & P.-W. (Diptera: Syrphidae)

*Lipoleucopsis praecox* de Meij. (Diptera: Chamaemyiidae)

#### Predators—Introduced

Class Hexapoda

Order Coleoptera

Family Derodontidae

*Laricobius erichsonii* Rosen. This beetle has been introduced each year from 1951 to 1955, is considered to be well established in most of the liberation areas and is the most promising of the recent introductions. It is univoltine. The larvae feed on the intermediate and adult stages of the hiemosistentes generation early in the summer and on the eggs of the aestivosistentes generation. Large populations have been observed and studied and it has been found that predation on the first generation generally results in a much smaller second generation than normally occurs in the absence of this predator. Predation by adults occurs in early spring and in mid-summer but, compared with predation by the larvae, is relatively unimportant.

Family Coccinellidae

*Pullus impexus* Muls. This species has been introduced each year from 1951 to 1955. It has progressed through several generations and is considered to be established in most areas where releases were made, although its increase and spread have been slow. The species has one generation per year, the larvae feeding in early summer on the second and third instars and adults of the first prey generation and on the eggs of the second generation. Adults also feed on these same stages and are active from mid-May to the end of August.

*Aphidecta oblitterata* L. This species was introduced in 1941, 1951, 1952 and 1955. There was no survival from the first three releases. Progeny were obtained from the 1955 release and it is not yet known whether the species is capable of becoming established in Eastern Canada. It is univoltine, both larvae and adults feeding on the second and third instars and adult stages of the first prey generation and on the eggs of the second generation. Mesnil (1950) records the fact that it is a non-specific feeder and that it is found feeding on both *A. piceae* and *A. nusslini* (Börner) on the twigs in Europe.

Order Diptera

Family Chamaemyiidae

*Cremifania nigrocellulata* Cz. Adults of this fly have been introduced each year from 1952 to 1955. Establishment has occurred in several release areas but spread to date has been limited. A spring and a summer generation occur each year, the larvae of these generations feeding on the first and second prey generations respectively. Eggs, second and third instars, and adults are consumed. The first record of parasitism on *C. nigrocellulata* by the native pteromalid *Pachyneuron altiscutum* How. was obtained in 1955. Six adult parasites emerged July 27-29 from 25 first-generation puparia collected on July 13 at Fredericton; three emerged during the 1955-56 winter from second-generation puparia collected in September. Brown and Clark (1956) have described field identification characters for *C. nigrocellulata*.

*Neoleucopsis obscura* (Hal.). This species was introduced from 1933 to 1936, and in 1941. It has become well established and has spread over most of the

range of *A. piceae* in Eastern Canada (Brown, 1947) with the exception of Newfoundland, where a small number of adults was released in 1954. Two generations occur per year, one in the spring and one during the latter part of the summer. Larvae of these generations feed mostly on prey adults and eggs late in the developmental period of the first and second prey generations respectively. Reference has been made in the literature (Balch, 1952) to the fact that *N. obscura* becomes abundant only on very heavy prey infestations and this limits its control value. *N. obscura* is commonly parasitized by a pteromalid, *Pachyneuron altiscutum* How. Brown and Clark (1956) have described field identification characters for *N. obscura*.

#### Predators—Native

##### Class Arachnida

##### Order Acarina

##### Family Trombiidae

*Microtrombidium* sp. Immature forms of this small orange-red mite are found feeding on the second and third instars and occasionally on the adult stages of *A. piceae* during the early summer developmental period of the first generation. However, they are not abundant every year and, when they occur, they are usually found only on a small percentage of the infested stems in an area. On trees where the mites are abundant, up to four have been observed feeding on a single prey adelgid and predation by them has sometimes caused sufficient reduction of the prey that its second generation population has been very small. Balch (1952) reports prey mortality caused by this mite as high as 25 per cent on some trees.

##### Class Hexapoda

##### Order Hemiptera

##### Family Anthocoridae

*Tetraphleps americana* Pars. Nymphs were observed feeding on adult *A. piceae* on July 9, 1956. Nymphs and adults were collected from July 4-16. This is the first record of this species as a predator on *A. piceae*.

*Tetraphleps canadensis* Prov. This uncommon species has been observed feeding on eggs and adults (Atwood, 1933).

##### Family Miridae

*Psallus piceicola* Kngt. This species, which is not common, was found feeding on an adelgid on larch, *Larix laricina* (DuRoi) K. Koch, and was successfully transferred to *A. piceae* (Atwood, 1933; Balch, 1952).

##### Order Neuroptera

##### Family Chrysopidae

Two unidentified species of chrysopid larvae have been observed feeding on *A. piceae* (Atwood, 1933).

##### Family Hemerobiidae

*Hemerobius humulinus* L. This hemerobiid is a common, but never abundant, predator on the second and third instars and adult stage of the first adelgid generation.

*Hemerobius stigmaterus* Fitch. This species has been found occasionally as a predator on *A. piceae* (Balch, 1952).

##### Order Lepidoptera

##### Family Lycaenidae

*Feniseca tarquinius* (Fabr.). A dozen larvae were recorded feeding on the balsam woolly aphid at Old Town, Maine in August 1946 (Brower, 1948).

## Order Coleoptera

## Family Coccinellidae

*Coccinella monticola* Muls. Atwood (1933) reports finding this species feeding on an adelgid on larch and successfully transferring it to *A. piceae*. *C. monticola* is a common predator on the balsam twig aphid, *Mindarus abietinus* Koch, and when this aphid is abundant, as in 1951, larvae and adults of the coccinellid are found commonly on stem infestations of *A. piceae*.

*Cleis picta* Rand. Atwood (1933) found a larva feeding on *A. piceae*. Adults are observed occasionally on infested trees. In 1955 they were more common than usual.

*Anatis quindecimpunctata* Oliv. Atwood (1933) recorded two larvae feeding on *A. piceae*. Adults and larvae are observed infrequently on infested stems.

*Chilocorus stigma* Say. Larvae and adults of this species were found by Atwood (1933) feeding on *A. piceae* but were not numerous enough to be an important factor in control. Larvae were numerous during late July 1953 on adelgid-infested trees but were not observed feeding on *A. piceae*, which at that time was mainly in the aestivating neosistens stage. This is a regular predator on the beech scale, *Cryptococcus fagi* (Baer.), and often becomes very numerous on infestations of the scale.

## Order Hymenoptera

## Family Formicidae

An unknown species of small ant has been observed on one occasion in 1953 feeding on intermediate instars of the second prey generation.

## Order Diptera

## Family Syrphidae

*Syrphus torvus* O. S. This is a common predator that feeds early in the summer on eggs, intermediate instars and adults of the first prey generation. It is sometimes numerous but has not been shown to be responsible for appreciable control of the prey except under cage conditions. Parasitism by an ichneumonid, *Syrphoctonus agilis* (Cress.), and a pteromalid, *Pachyneuron allograptae* Ashm., is frequent and sometimes heavy. Another pteromalid, *Asaphes* sp., has been recorded as a parasite.

*Metasyrphus lapponicus* (Zett.). Atwood (1933) recorded this species as of fairly general occurrence feeding on *A. piceae* in May and pupating in June. It is observed in small numbers each year. The larvae feed on second and third instars and prey adults.

*Metasyrphus wiedemanni* (Johns.). Atwood (1933) recorded this species feeding in August on the second generation. Larvae are difficult to distinguish from *M. lapponicus* except by the time of feeding. They feed on second and third instars and adults.

*Cnemosdon* sp. (*coxalis* Curr.?). The gray larvae appear feeding on second and third instars and adults of the second prey generation late in the summer. Only one adult has been obtained from many rearing attempts. *Syrphoctonus* sp. and a chalcid parasite have been reared from field collected puparia.

## Family Chamaeymiidae

*Neoleucopis pinicola* Mall. This is a common predator on the adelgid, *Pineus strobi* (Htg.), on white pine. Puparia are sometimes found on infested bark but larvae have on only one occasion been observed feeding on *A. piceae*. Evidence indicates that this species is an occasional predator on *A. piceae*. Parasitism by a pteromalid, *Pachyneuron altiscutum* How. has been observed.

*Leucopina americana* (Mall.). This insect is predacious on other adelgids and became established on *A. piceae* following introduction of the latter into Canada. Since *N. obscura* became established, *L. americana* has become less abundant, although it is still recorded regularly. The species seems more numerous in Newfoundland than in the Maritime Provinces at the present time; this may be related to the absence of introduced predators. Carroll (1956) reports finding up to 135 puparia per square foot on parts of a few heavily-infested trees at Wild Cove Point, Newfoundland in 1955, before any of the introduced species have become well established. Atwood (1933) recorded larvae feeding on intermediate stages of the prey and intimated that two generations occurred per year. This has been verified by recent observations. Parasitism by *Pachyneuron altiscutum* How. is heavy. Brown and Clark (1956) have described field identification characters for *L. americana*.

#### Probable Predators

The following species, found as larvae on infested balsam fir and belonging to generally predacious groups, are believed to be occasional predators of *A. piceae* although feeding has not been observed.

##### Class Arachnida

###### Order Acarina

###### Family Erythraeidae

*Balaustium* sp., a large red mite, is found on infested trees during the early summer.

##### Class Hexapoda

###### Order Neuroptera

###### Family Chrysopidae

*Chrysopa cockerelli* Bks. This species is occasionally found on infested balsam fir.

*Wesmaelius longifrons* Wlk. In May 1956 one cocoon was collected from infested fir; the adult emerged in the laboratory. Another adult was collected on infested fir on August 6.

###### Order Diptera

###### Family Cecidomyiidae

*Epimyia* sp. Larvae have been reared from infested fir.

#### Possible Predators

The following species are found occasionally on infested balsam fir mostly as adults, and belong to genera containing predacious species in the adult stage.

##### Class Arachnida

###### Order Acarina

*Luccopia lucorum* (Koch), *Jugatala* sp. and *Gymmobates* sp. These are sometimes common, apparently feeding on remains of the adelgids after death. They may also feed on an alga which is common on the bark.

##### Class Hexapoda

###### Order Diptera

*Atrichopogon* sp. (Family Ceratopogonidae).

*Dasyhelea* sp. (Family Ceratopogonidae).

*Rhagio mystacea* Macq. (Family Rhagionidae).

*Tachypeza fenestrata* (Say) (Family Empididae).

*Philia breviceps* (LW) (Family Empididae).

*Neurigonia deformis* V.D. (Family Dolichopodidae).

*Neurigonia maculata* V.D. (Family Dolichopodidae).

- Medeterus veles* LW (Family Dolichopodidae).  
*Medeterus vanduzeei* Curr. (Family Dolichopodidae).  
*Medeterus frontalis* V.D. (Family Dolichopodidae).  
*Medeterus balteralis* V.D. (Family Dolichopodidae).  
*Medeterus* sp. (Family Dolichopodidae).  
*Epistrophe cinctellus* Zett. (Family Syrphidae).  
*Epistrophe genualis* Will. (Family Syrphidae).  
*Syrphus ribesii* var. *vittafrons* Shan. (Family Syrphidae).

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### Colorimetry of Shiny Biological Specimens

By W. E. K. MIDDLETON AND G. W. WYSZECKI  
National Research Council, Ottawa, Canada

Professor John Stanley of McGill University recently asked the National Research Council for assistance in specifying the colors of flour beetles (*Tribolium*). These insects are small (3 or 4 mm. long), rounded, dark, and shiny, and therefore present a somewhat colorimetric problem. It is felt that the solution of this problem may be of some general interest.

The small size of the specimens seemed to preclude physical methods of colorimetry. It was felt that the most likely visual method would be direct comparison with Munsell papers or other standard colored surfaces<sup>1</sup>. The difficulty with this was the very different appearance of the smooth, flat paper and the shiny, rounded beetle.

Fortunately a rather similar problem of diverse surface appearance had been solved in this laboratory a few years ago, in connection with bronze paints<sup>2</sup>. It was found that almost completely diffuse illumination would entirely conceal the metallic lustre of such paints and make possible their direct comparison with Munsell papers. The diffuse illumination was provided by allowing the sample and standard to close an opening in a hollow whitened sphere containing a small lamp, direct light from the lamp being prevented by a screen from reaching the

<sup>1</sup>For a general discussion of color systems, see D. B. Judd, *Color in Business, Science, and Industry*, New York 1952, Wiley, pp. 172 ff.

<sup>2</sup>W. E. K. Middleton and A. G. Mungall, Colorimetry of Bronze Paints, *J. Opt. Soc. Am.* 42: 969-970, 1952.

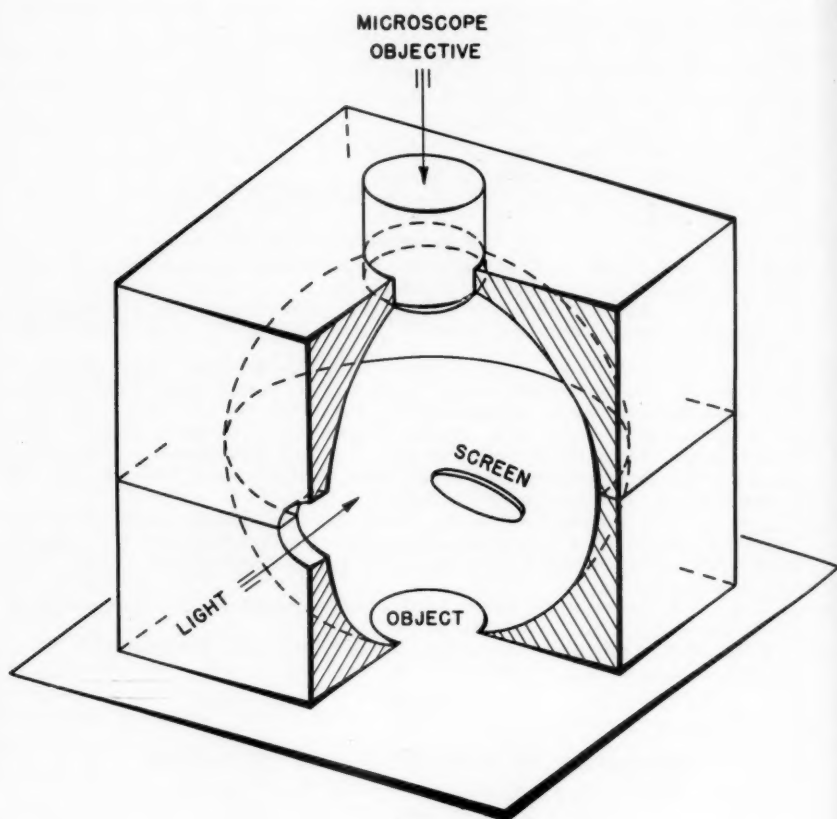


Figure 1

sample and standard. The latter were observed through another small opening diametrically opposite.

For the present measurement a small sphere was machined in two blocks of aluminum alloy (Fig. 1). The diameter of this sphere was chosen to suit the working distance of a microscope objective of 50 mm. focal length. Since a lamp could not be placed inside, a third opening was provided through which light from a small microscope lamp could be projected. A small screen conceals the illuminated spot from the sample. The entire inside surface, including the screen, was painted with a flat white paint followed by several coats (sprayed) of a water paint composed of carboxy-methyl-cellulose, 1 gm., barium sulphate U.S.P., 100 gm., distilled water to the proper consistency for spraying<sup>3</sup>. Other white paints would probably be entirely adequate as long as they are non-glossy.

A blue filter (Chance OB-9 or Corning 5600), 4 mm. thick, converts the light from the microscope lamp into an acceptable substitute for average overcast daylight.

This illumination makes the flour beetle look quite flat and entirely without

<sup>3</sup>W. E. K. Middleton and C. L. Sanders, An improved sphere paint. *Illum. Eng. (N.Y.)* 48: 254-256, 1953.

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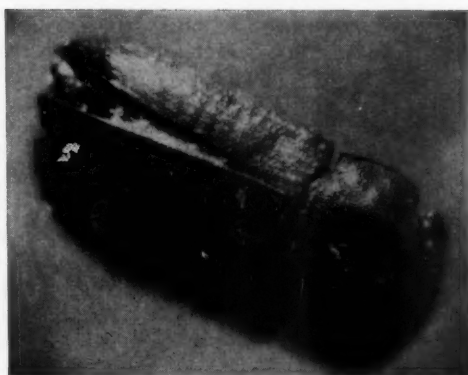


Figure 2

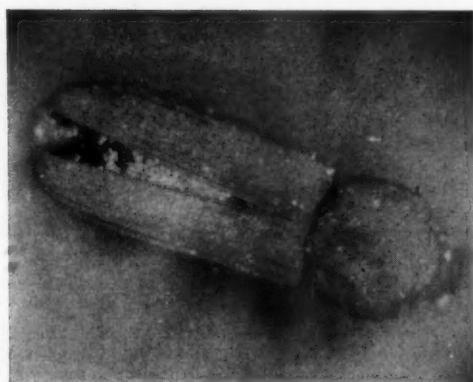


Figure 3

gloss. To make a measurement, pieces of Munsell paper are interchanged beneath the specimen until a satisfactory color match is found, or until it is clear that the color of the specimen lies in the region of the color-space bounded by two or more papers, when an interpolation is necessary. It is probable that for most taxonomic purposes the nearest Munsell paper will be a sufficiently precise specification.

Figures 2 and 3 will give some idea of the appearance of the same beetle when illuminated with the special illuminator and under ordinary lighting, respectively.

The method could easily be extended to larger specimens by the use of a larger sphere, perhaps with a simple lens at the top. A useful improvement would be a spring-operated stage below the sphere, to facilitate replacing the specimen and papers. Such an arrangement is shown in reference (2).

Besides its use in entomology, this method of colorimetry might well be applied to seeds. It should be clearly understood that colors specified in this manner are somewhat conventional, but the justification for the method lies in the extreme difficulty of making color matches between rounded shiny objects and flat papers in any ordinary lighting.

# ***Ichneumon lariae* Curtis** **A Critical Study on this Arctic Species and its Closely Related Forms**

By GERD H. HEINRICH  
Dryden, Maine

## ***Ichneumon lariae* Curt.**

**Syn. *Cratichneumon aurivillii* Roman (new Syn.)**

Orig.: *Ichneumon lariae* Curtis, 1835, in Ross, Appendix to the Narrative of a Second Voyage in Search of a North-West Passage, p. LXI, fig. Pl. A, 1.

*Ichneumon lariae* Schiodte, 1857, Till. t. Rink. Grønland, 59.  
[no description.]

*Ichneumon lariae* Auriv., 1890, Bih. Svensk. Vet. Akad. Handl. XV, P. 4, p. 31, n. 16, fig. Tafl. 3, 11 and 11a.

[Description of one ♀ specimen from Greenland possibly belonging to this species: black with red scut., legs, venter, sides of abdomen and greater part of antennae.]

*Ichneumon lariae* Roman, 1914, Mem. Ac. Sc. St. Petersburg.

[4♀ from arctic East Siberia are considered as representatives of a new subspecies, *asiaticus* Rom. of *Ichn. lariae* Curt. The specimens recorded before from Greenland by Schiodte, 1857, and Aurivillius, 1890, loc. cit. are considered and named as a different new species *aurivillii* Roman which is contributed to the genus *Cratichneumon* Thoms. on account of the smooth sculpture of postpetiole.]

*Cratichn. aurivillii* Roman, 1916, Arkiv for Zoologi X, 22 p. 5.

[Considers specimen described by Aurivillius loc. cit., 1890, as different from *lariae* Curt. and as new. Contributes this new species to *Cratichneumon* on account of the smooth postpetiole.]

I. (*Cratichn.*) *aurivillii* Henriksen & Lundbeck, 1198, Meddel. om Grønland XXII, p. 520.

[Bibliographie 1895-1907. Distribution: West Greenland north to 70°20': many localities. East Greenland: one record only: Hekle Haven.]

*Cratichn. aurivillii* Roman, 1930, Am. Mag. Nat. Hist. 10 p. 282.

[1♀ on heath, Kugssuk, Greenland. The least rare species of *Ichneumoninae* in Greenland. Species never found in palaearctic, therefore suggested as being derived from America.]

*Ichneumon aurivillii* Roman, 1933, Skrifter om Svalbard Nr. 53, p. 617.

[Transfers species to *Ichneumon* L. Describes a black male with vivid red legs as "nearly certainly" belonging to it.]

**Type Locality:**—East shore of Boothia Peninsula between 70° and 73°N.

[Perhaps Fury Beach between 72° and 73°N because the expedition stayed here on the way back during summer 1832 when the caterpillars of *Byrdia rossi* Curt. were collected.]

**Holotype:**—According to information recently granted by J. F. Perkins, British Museum, no type specimen of *I. lariae* Curt. was discovered in England. The holotype therefore is regarded as lost.

**Distribution:**—Boothia Peninsula, Greenland, Baffin Island (new record), Southampton Island (new record).

## **Preface**

The description of this species was founded on two specimens, one captured, the other said to be reared from the Liparid *Byrdia rossi* Curtis. As the types are lost, we depend for re-identification of the species on the description, the coloured picture and the host record.

The Canadian National Collection contains 2 specimens of an *Ichneumon* species reared from *Byrdia rossi* Curtis (♀ from Spence Bay, N.W.T., ♂ from

<sup>1</sup>This contribution to our knowledge of the *Ichneumoninae* of the boreal parts of Canada and of Alaska is based mainly on material obtained by the Northern Insect Survey, which is a co-operative project of the Canada Department of Agriculture and the Defence Research Board, Canada Department of National Defence.

Repulse Bay, N.W.T.) and 2 captured specimens evidently belonging to the same species (♀ from Yukon Territory, ♂ from Frobisher Bay, Baffin Isl.). Unfortunately none of the mentioned specimens matches the picture of *I. lariae* Curt., either in colour pattern or in size.

There is a series of 4 specimens of a different *Ichneumon* species from Greenland (Sonderstrom Airbase) in the Canadian National Collection, which matches—one specimen exactly—the picture of *I. lariae* Curtis. This species, however, belongs morphologically to the bulk of the genus and therefore may not be expected to be a parasite of Liparid larvae. As a matter of fact, one of the 4 specimens was reared from an unidentified pupa of Noctuae.

Now the dilemma arises: The species matching the picture and description of *I. lariae* Curtis is not a parasite of *Byrdia rossi* Curt. while the species reared from *Byrdia rossi* Curt. does not match the picture.

One explanation seems to be possible: Curtis might have erroneously regarded his two specimens as belonging to the same species and then derived the host record from the one, the picture from the other. After thorough consideration of the facts I decided to accept this explanation. I regard the species matching the picture as representing *I. lariae* Curt. and shall describe the other species, which is the parasite of *Byrdia rossi* Curt., as *Ichneumon byrdiae* spec. nov.

*Ichneumon lariae* Curtis (in the conception above) seems to be one of the most common species of the Arctic region, accordingly most often mentioned in literature with the result of a complicated taxonomy, the latter due to the fact that this species evidently has an unusual high mutability in colour as well as in sculpture.

Roman's publication loc. cit. 1914 deserves a special discussion. As may be concluded from the wording of this article, Roman has never seen the type specimen of *I. lariae* Curtis. Nevertheless he considers the 4 discussed females from eastern Siberia (all from east of the mouth of the river Lena) as belonging to this species, evidently on account of Curtis' coloured picture, though the Siberian specimens are somewhat different in colour and therefore named as a new subspecies *asiaticus* Roman. As main support for the somewhat hypothetic identification of the Siberian specimens Roman mentions the fact that *Byrdia rossi* Curt., the host of *I. lariae* as recorded by Curtis, is replaced on the Siberian side of the Bering Strait by *Byrdia groenlandica* Wocke, a closely related species. This argument seems to be meaningless, since no one of the Siberian specimens was reared from this host. Taking, nevertheless, the correct identification of the Siberian specimens as *I. lariae* Curtis for granted now, Roman derives from these specimens the character of the sculpture of postpetiole as a criterion of the species *lariae* Curtis for proving that the specimens recorded under the same name by Schiodte and Aurivillius (loc. cit. 1897 and 1890) from Greenland, which have a different sculpture of postpetioles, belong to a new species (and even another genus) named in the footnote as *Cratichneumon aurivillii* Roman.

This whole deduction was reconstructed here in full detail to show that it lacks any concrete foundation. There is no proof whatsoever that the Siberian specimens really are *I. lariae* Curtis and therefore there is no proof either that the specimens recorded under this name from Greenland are not.

The main difference mentioned by Roman between both populations is that the postpetiole in the Siberian specimens is said to be "very delicately, sometimes indistinctly" striated, in the Greenland specimens to be "polished". A mutability of this degree seems to be peculiar to the species *I. lariae* Curtis in the conception of this paper. It was observed especially in *I. lariae subarcticus* ssp. nov.

(described below) and in less degree also in *I. lariae lariae* Curtis, though in both subspecies the polished sculpture of postpetiole prevails. Thus there seems to be no doubt that *I. aurivillii* Roman is a synonym of *I. lariae* Curtis as interpreted here. Besides, I believe it to be quite possible, though not yet finally proven, that ssp. *asiaticus* Roman geographically represents the same species.

With regard to the generic position of the species the polished postpetiole seems not to be reason enough to place it into the genus *Craticheumon* Thoms. since the rest of morphology indicates a genuine *Ichneumon* L. and the sculpture of postpetiole tends to mutate into feeble striation individually as well as perhaps geographically.

#### Redescription

based on 4 ♀ from Greenland (Sonderstrom Air Base)

2 ♀ from Baffin Island (Cape Dorset and Nettling Lake)

1 ♀ from Southampton Island (Coral Harbour)

#### Female

Head and sterna black, face usually with a red mark in the middle. Mesonotum with scutellum red. Pleura and propodeum red and black in different extent from nearly entirely red to nearly entirely black. Abdomen red with black marks of variable size and extent on the disk of tergite 2 to 4, or 5, or 6, or 7, sometimes tergite 4-7 totally black. Legs red, coxae and trochanters varying from partially red to entirely black. Antennae red, dark towards the apex. One of the four specimens from Greenland with a whitish spot on the seventh tergite. Length: 10-11.5 mm.

Head transverse with temples only slightly narrowed behind the eyes. Malar space about as long as the width of mandible base. In front view cheek profile straight and converging considerably towards base of mandibles. Middle field of face elevated. Mandibles normal, the upper tooth being somewhat longer than the lower. Punctuation, except lower part of cheeks, rather strong.

Flagellum with 37-39 joints, filiform, slender, fairly long, of even width throughout, neither broadened beyond the middle nor attenuated at the apex, inconspicuously flattened on one side towards the end, the first joint being somewhat less than twice as long as wide at the apex, about the 12th joint square, about the last 15 joints transverse.

Mesonotum and scutellum shining with shallow and not dense punctuation. Scutellum slightly convex.

Propodeum fairly short with the area supermedia square or slightly broader than long.

Postpetiole without clearly separated middle area, smooth and shining, polished or with some indistinct, hardly visible striae and a few scattered punctures.

Gastrocoeli of triangular shape, shallow, the interval usually distinctly broader than one of them.

Coxae III with a little, not very distinct brush, densely and rather strongly punctured.

Mesosternum and epicnemial area strongly and densely punctured as the coxae.

The species seems to be widespread over the Arctic islands extending southward into the subarctic regions of the American continent in Labrador and the Northwest Territories, where it is replaced by the following subspecies mainly signified by reduction of melanistic characters peculiar to the island populations.

The occasional occurrence of unmelanistic mutants also among the island populations has to be expected and is recorded as follows: 1 ♀, N.W.T. (Cam-

bridge Bay): Besides middle of the face, a mark on each side of it and the inner orbits partially red. Red furthermore: Propodeum (except areae coxales), pro-, mesopleura and coxae. Black marks of abdomen reduced.

1 ♀, N.W.T. (Spencer Bay): As before, but black colour of head reduced to cheeks, ocellar region and occiput.

Male

Roman described loc. cit. 1933 a single male specimen from Greenland, which he supposed to belong to *I. aurivillii* Roman, as entirely black with the legs vivid red except coxae and trochanters. According to description head and thorax are black haired, the area superomedia is transverse, the postpetiole distinctly striated. This association might be correct, but it might just as well be wrong. It still lacks confirmation by biological facts.

*Ichneumon lariae* Curtis  
*subarcticus* ssp. nov.

Type Locality:—Salmita Mines (65°05'N, 111°15'W), Northwest Territories, Canada.

Holotype:—♀, J. G. Chillcott, 30.VI.1953, No. 6410 in Canadian National Collection, Ottawa.

Paratypes:—16 ♀♀ from type locality, J. G. Chillcott; 1 ♀, N.W.T., Repulse Bay, J. E. H. Martin, 21.VI.50; 1 ♀, Manitoba, Churchill, J. G. Chillcott, 29.VI.52; 1 ♀, Quebec, Ft. Chimo, R. H. MacLeod, 21.VI.48; in Canadian National Collection, Ottawa, and collection of G. H. Heinrich, Dryden, Maine.

Differs from *lariae* Curt. by decrease of melanistic colour pattern. Abdomen entirely red. Head and pleurae entirely or mostly red. Mesosternum and often prosternum black, the former at least to the line where sternauli would be situated if present. Legs red, rarely coxae II and III partially black.

	Head				Thorax			Propodeum			Abdomen			Legs	
	red	cheeks ÷ black	cheeks & frons ÷ black	black (except face & clypeus)	red	only mesosternum black	pro- and meso-sternum black	red	only areae coxalis black	metapleura black up to carina metapleurals	red	yellow mark tergite 7	yellow mark tergite 6 & 7	red	coxae II & III partially black
16 specimens from type locality.....	10	1	4	1	1	8	7	9	1	6	15	1	-	13	3

Besides the above mentioned variability of colour an essential mutability also in sculpture and even to a certain degree in the proportions of joints of antennae has to be noted. To me, however, it seems impossible to separate several species on account of such differences. I presume that a somewhat unusually high mutability has to be regarded as a peculiar character of this arctic and subarctic species. The final proof may only be procured by rearing it.

***Ichneumon lariae* Curtis  
*labradoris* ssp. nov.**

*Type Locality*:—Hopedale, Labrador, Newfoundland.

*Holotype*:—♀, W. W. Perrett, 5.VII.1928, C.N.C. No. 6411, in Canadian National Collection, Ottawa.

*Paratypes*:—43 ♀♀, from type locality, W. W. Perrett, 1924-28, in Canadian National Collection, Ottawa and in collection of G. H. Heinrich, Dryden, Maine.

**Female**

Agrees with *liariae subarcticus* Heinr. in morphology, sculpture and colour, differs, however, considerably and constantly in size, a fact becoming strikingly evident by comparing the broad series of paratypes from both type localities. Average total length of 10 specimens of *labradoris* ssp. n.: 12.5 mm. Average width of head measured:

in 5 specimens of ssp. *subarcticus* Heinr.: 1.9 mm.

in 5 specimens of ssp. n. *labradoris*: 2.05 mm.

Mutability of sculpture of postpetiole peculiar to the whole conspecies is evident also in this subspecies changing from smooth to distinctly though finely striated.

Colour evidently less mutable than in ssp. *subarcticus* Heinr.: Red. Black only: mesosternum usually to the place of sternaui, sometimes totally, epicnemial field and prosternum partially or entirely, sometimes base of coxae III and area coxalis.

***Ichneumon lariae* Curtis  
*ssp. asiaticus* Roman**

*Type Locality*:—Chara-Ullach Mountains, East of the river Lena, East Siberia.  
*Holotype*:—Not selected.

Differs from *liariae lariae* Curt. according to description by darker colour. The black colour pattern, however, as recorded by the author, still falls into the frame of mutability of American specimens as given in the redescription of *I. lariae* Curt. above. There remains only one character of diagnostical value for the subspecies: the black antennae.

2 specimens with partially black pronotum but red tergites 6-7, length: 11-12 mm.

3 specimens with red pronotum but black tergites 6-7, length: 9-10 mm.

Whether the original description refers to one or two species and whether or not specimens included really represent a subspecies of *I. lariae* sensu meo remains to be proven.

***Ichneumon alpestriformis* Viereck ♀**

*Amblyteles* (*Pterocormus*) *alpestriformis* Viereck, 1923, N. American Fauna, 46, p. 234.

*Type Locality*:—St. Paul Island, Bering Sea, Alaska.

*Holotype*:—♀, A. G. Whitney, 22.VI.1913, U.S.N.M. No. 26475 in the U.S. National Museum, Washington, D.C.

*Paratypes*:—2 ♀♀, from type locality, in U.S. National Museum.

*Distribution*:—Alaska: St. Paul Island, St. George Island, St. Matthew Island (new record).

**Female**

Condensed from original description: Head reddish except cheeks, malar space and antennal basin which are black. Basal fourth of antennae reddish, rest blackish. Thorax including scutellum and postscutellum reddish. Abdomen red, the middle of its surface from the end of 2nd tergite to the base of 5th tergite

broadly black, 6th and 7th tergite with yellow spot. Legs mostly reddish, coxae and trochanters mostly black, coxae III reddish above. Area supermedia nearly quadrate. Postpetiole dullish, almost impunctate. Length: 9 mm.

1 ♀, in the Canadian National Collection, from St. Matthew Isl., R. Ranssch, 19.VIII.54, was compared by W. R. M. Mason with the type and found to be specifically identical. This specimen lacks the melanistic pattern on 2nd to 5th tergite present in the type. Colour of head agrees with the latter. All coxae are partially red. Black are: Pro- and mesosternum, epicnemial field and area coxalis. Rest of thorax and propodeum red. The two anal spots present. No distinct brush. Postpetiole smooth.

This species is closely related to *I. lariae* Curt. (= *aurivillii* Rom.) and agrees with the latter especially in the smooth sculpture of postpetiole and in the morphology of antennae. I presume that it geographically replaces *I. lariae* Curt. On account of the following differences it might be considered, however, as a good species rather than as a subspecies:

- 1) In front view cheek profile considerably more narrowed towards mandibles than in *I. lariae* Curt.
- 2) Tarsi I and II slightly shorter and relatively broader, besides more densely hairy than in *lariae* Curt. First joint of tarsi I about 2.4 times longer than wide at the apex in *alpestriformis* Vier., 2.65 times longer in *lariae* Curt.
- 3) Yellowish spots on 6th and 7th tergite evidently constant. (In *lariae* Curt. including *subarcticus* ssp. nov. present only in rare mutants.)

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## Studies on the Balsam-Fir Seed Chalcid, *Megastigmus specularis* Walley (Hymenoptera, Chalcididae)<sup>1</sup>

By A. F. HEDLIN

Forest Biology Laboratory, Victoria, B.C.

### Introduction

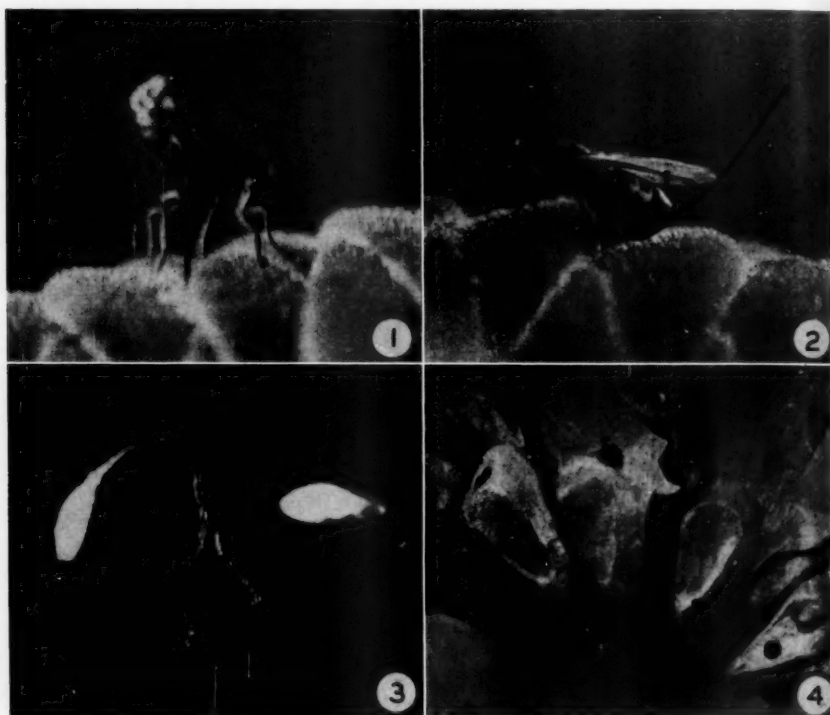
The balsam-fir seed chalcid, *Megastigmus specularis* Walley, destroys a high percentage of seeds of balsam fir, *Abies balsamea* (L.) Mill. The insect was first recorded in Canada in 1928 from New Brunswick and in 1932 was described by Walley (1932). It has been taken in the United States as far west as Minnesota (Peck, 1951). In 1953 the insect was reared from seeds of balsam fir taken at the Forest Nursery Station, Indian Head, Saskatchewan. Further investigations in 1954 showed the insect to be abundant at Indian Head, and also in natural stands of balsam fir in Riding Mountain National Park, Manitoba.

In 1955, a study of the life history and habits of the insect was carried out at Indian Head. Material from the Prince Albert and Riding Mountain National parks was examined for data on distribution. Conditions were generally satisfactory for carrying out this study; the balsam-fir cone set was excellent, the insect population was high, and weather was good during most of the period of adult activity.

### Methods

In September, 1954, cones were collected from balsam-fir trees on the Forest Nursery Station at Indian Head. These were placed in screen cages and left

<sup>1</sup>Contribution No. 316, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.



Figs. 1-4. *Megastigmus specularis* Walley. 1, Female selecting oviposition site in balsam-fir cone. 2, Female with ovipositor fully inserted in cone. 3, Eggs. 4, Emergence holes in balsam-fir seeds.

to overwinter outside. In May, 1955, some seeds from these were placed in jars in the insectary. Material was observed daily for data on emergence. During the period of adult activity observations were made in the field and insectary for data on mating, oviposition, feeding, and flight habits.

In the insectary, larvae removed from seeds and placed in gelatin capsules, were observed daily. Data on pupation and pupal development were recorded.

Seeds from the 1955 crop were collected and examined regularly throughout the growing season. Eggs and developing larvae were preserved for examination.

#### The Developmental Stages

##### Egg

The egg of *M. specularis* (Fig. 3) is composed of an elongate-oval body and two slender pedicels, one long (anterior) and the other short (posterior) (Clausen, 1940). Sometimes the posterior pedicel is absent. The average total length of 13 eggs at time of removal from the seeds was 1.23 mm. Average dimensions of individual parts were: body length 0.29 mm., width 0.15 mm., anterior pedicel 0.91 mm., and posterior pedicel 0.03 mm. in length. The egg is milky-white in colour and the surface smooth and glossy. When exposed to the air it becomes dehydrated and collapses very quickly.

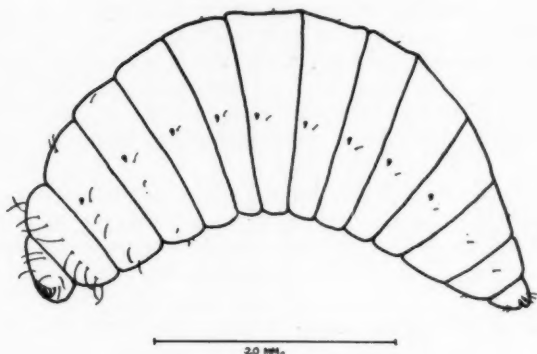


Fig. 5. Fifth-instar larva, *M. specularis*.

#### Larva

Examinations of larvae collected during the season showed that there are five instars. Body length varies considerably within instars, but head capsule width is comparatively constant and is the characteristic used in separating instars. The ranges for body length and head-capsule widths are respectively: first instar, 0.32 to 0.57 and 0.11 to 0.15; second, 0.46 to 0.94 and 0.18 to 0.23; third 0.77 to 1.14 and 0.24 to 0.29; fourth 0.90 to 2.36 and 0.31 to 0.41; fifth, 1.31 to 4.20 and 0.45 to 0.53.

The fifth instar larva is yellowish-white. The body is strongly arched and tapers towards both ends.

The number of setae on the body segments (Fig. 5) is not always constant. On the head there is a single seta dorsad and another laterad of each mandibular base, with a third situated dorsally to form a triangle with the other two; there are two pairs of setae near the posterior dorsal margin of the head. There are 12 setae arranged in a circle around the first thoracic segment and usually 10 around each of the second and third although this number is not constant. These setae become progressively smaller posteriorly. There are nine pairs of spiracles, one on each of thoracic segments II and III and abdominal segments I to VII inclusive. There is one seta behind each spiracle on abdominal segments I to VII, and in corresponding positions on segments VIII and IX; segment X has two pairs of setae above and one pair below the anus. Minute dorsal setae are present on some abdominal segments.

#### Pupa

The newly formed pupa is entirely white. Within a few days the eyes become pale orange, then gradually change to deep crimson. They are the first organs to start changing colour following pupation. Observations made on *M. specularis* agree with the detailed account of the pupa of *M. nigrovariegatus* Ashmead given by Milliron (1949).

Male pupae average 2.50 mm. in length, and 0.98 mm. in width through the thorax; females average 2.88 and 1.11 mm.

#### Life History

##### Adult

Adults emerge in the spring from infested balsam-fir seeds which have overwintered on the ground. Emergence is effected by cutting a small circular hole

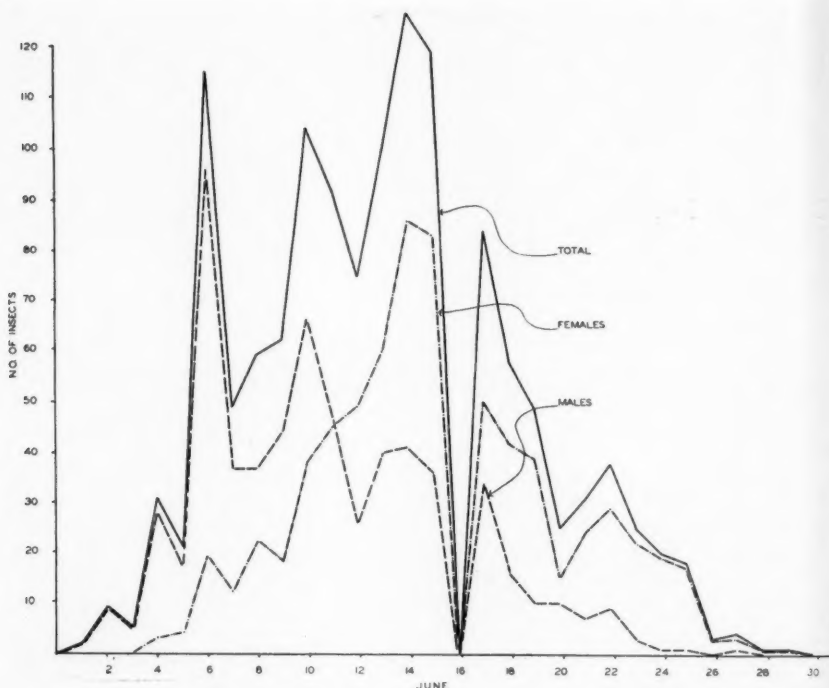


Fig. 6. Graph of daily emergence data for 623 male and 704 female *M. specularis* adults, Indian Head, 1955.

in the seed coat (Fig. 4). One thousand, three hundred and twenty-seven adults for which data were recorded, emerged during the period June 1 to 29 (Fig. 6). Males commenced and completed emergence at an earlier date than females. The ratio of males to females was 47:53.

Pollen commenced shedding from male balsam-fir cones on May 30, two days before insects began to emerge.

The insects were not observed to feed in the field but fed readily in the insectary on saturated sugar solution. Thirteen males and 23 females which were fed, lived for average periods of nine days and 13 days respectively; the average maximum and minimum daily temperatures were 68° and 48°F. Twenty-nine males and 28 females reared without access to food lived for average periods of six and seven days respectively; the average maximum and minimum daily temperatures were 61° and 47°F.

Since the insects emerge over a period of one month and live nearly two weeks, the period of adult activity is postulated to be about six weeks.

Mating was not observed in the field. In the laboratory, one pair mated on the day of emergence and again the following day. Prior to mating, the male moves its body from side to side and approaches the female with vibrating antennae. It mounts the female, placing the prothoracic legs on the head, the mesothoracic legs on the bases of the wings and the metathoracic legs on the edges of the wings, of the female. The antennae of the male vibrate rapidly

through a small arc close to those of the female. Occasionally it moves them through a wider arc and brings them into contact with the basal joints of the female's antennae; at the same time it moves the body forward to bring the heads of the pair into contact. The male may carry on this courtship for several minutes. When ready to mate, the male swings beneath the female and copulates caudo-laterally. The male mounts the female again for a short period and then leaves it.

During cool weather the adults are inactive but they will fly actively at higher temperatures whether the sky is clear or cloudy. Although maximum activity occurred during the warmest part of the day, insects were observed ovipositing as early as 7.30 a.m. and as late as 8.45 p.m. when temperatures were 58°F. and 55°F. respectively.

During the oviposition period insects were present in large numbers around the cones of balsam fir but were not observed in other places. Hussey (1955) demonstrated that before fertilization, females of *M. spermotrophus* are not attracted by the odour of the host tree, but once fertilized, they are. This may be true of *M. specularis*.

A number of attempts to induce oviposition under laboratory conditions failed. In the field, oviposition occurred during the period June 15 to 29 inclusive. Large numbers of insects, male as well as female, were present on the cones and around the upper crown. Females oviposited freely and were apparently not influenced by the presence or actions of the observer.

A female preparing to oviposit walks slowly around on the cone examining the surface with her antennae (see also Miller, 1916). It turns around several times and stands in one place for some time before commencing the act of oviposition. It raises its abdomen stroking it with the metathoracic legs, then draws the legs posteriorly along the abdomen to the base of the ovipositor, draws the abdomen forward until it is strongly arched, and inserts the tip of its ovipositor into the cone scale (Fig. 1). It then releases the ovipositor sheath which assumes its normal position, and with a rhythmic pumping motion of the body, thrusts the ovipositor for its full length into the cone (Fig. 2). When the operation is completed it quickly withdraws the ovipositor which assumes its normal position within the sheath. The ovipositor is always inserted at the lowest exposed portion of the cone scale selected (Fig. 2). The insect always faces the base of the cone and since balsam-fir cones are upright, the insect faces downwards. Miller (1916) observed that *M. spermotrophus* acts in the same way, but since Douglas-fir cones are pendant the insect faces upwards. During a period of one hour a female inserted its ovipositor eight times in selected spots in one cone; the time for each insertion varied from one minute twenty-five seconds to six minutes thirty seconds. Six false starts were made in which the sites were rejected after the tip of the ovipositor had been inserted.

On June 16, at the commencement of the oviposition period eleven balsam-fir cones ranged in length from 5.0 to 5.9 cm. and averaged 5.5 cm.; the widths averaged 1.7 cm. with little variation between cones.

#### Egg

Oviposition commenced on June 15. Eggs were obtained from seeds on June 16. Larvae were observed on June 24 which would indicate an incubation period of approximately eight days. At completion of oviposition there were five days between final oviposition and last recovery of eggs.

The egg is deposited within the seed embryo; a few exceptions were observed where the body or the anterior pedicel extended outside the embryo wall.

Multiple infestations occur frequently; 30 per cent of 335 seeds were infested with more than one egg, the maximum number per seed being six. Hussey (1955) observed as many as seven *M. spermatrophus* eggs in one Douglas-fir embryo.

#### Larva

Larvae pass through the first four instars rapidly, with slightly more than one month elapsing between the appearance of the first and fifth instars. The instars were present during the following periods: first, June 24 to July 13; second, July 5 to 20; third, July 15 to 26; fourth, July 20 to Aug. 8; fifth, July 27 to May.

The larval period extends for nearly 11 months, from time of egg hatching until the following spring when pupation occurs. When larvae remain in diapause the period is extended by at least another 12 months; 65 per cent of fifth-instar larvae in infested seeds from 1954 remained in diapause for at least one year. Hussey (1955) observed that this phenomenon is common in *M. spermatrophus*.

Although multiple infestations are common, never is more than one mature larva found in a seed. Milliron (1949) observed that several *M. nigrovariegatus* larvae may develop through approximately the third instar in the same seed if not in close contact in early development, but eventually were forced into contact and cannibalism resulted.

The larva feeds on the embryo, and on the cotyledons when they begin to develop. By the time the larva is fully grown the cotyledons are completely devoured. Feeding is confined to one seed; the larva completes its development within the seed in which the egg was deposited. External appearances of seeds are not visibly affected by larval feeding and therefore normal and infested seeds cannot be separated on this basis.

#### Pupa

Pupae are present for slightly more than one month; examination of infested seeds from caged material revealed pupae during the period May 14 to June 18.

Twenty-two male and eight female insects which pupated in individual gelatin capsules emerged after an average period of 23 days; the range for males was 21 to 25 days and for females 20 to 26 days.

#### Seed Losses

Seed losses caused by the chalcid varied from 22 to 57 per cent of potentially good seed. In 1954 and 1955 the seed losses at Indian Head were 30 and 57 per cent respectively, at Riding Mountain National Park 22 and 46 per cent respectively; and at Waskesiu in 1955, 45 per cent.

#### Acknowledgments

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(Received November 5, 1956)

## Annotated List of Spiders (Araneae) from Apple Trees in Nova Scotia<sup>1</sup>

By C. D. DONDALE<sup>2</sup>

Fruit Insect Section, Science Service Laboratory  
Kentville, Nova Scotia

Orchard spiders are important because of their predatory activities and their frequent abundance. They were recognized as a group needing study at the time Pickett *et al.* (1946) began their long-term investigation of orchard fauna. The identities of the species involved, and their influence on populations of orchard pests, are the main factors to be considered.

This paper presents a list of the species collected in the Annapolis Valley of Nova Scotia to date, together with brief comments of a general nature. Spiders have been collected in about 40 orchards since 1954. These orchards were subjected to a variety of cultural and pest control methods by the owners, but most were in sod cultivation, and under modified spray programs as described by Pickett and Patterson (1953). Collecting was done mainly by tapping lower branches of trees over an inverted, open umbrella, but specimens were also taken individually from crevices along tree trunks, and from trays under fumigated trees.

The list contains 77 species. Forty-eight of these are webbing species, and 29 non-webbing. Family names are arranged according to Kaston's (1948) monograph of Connecticut spiders; genera and species are listed alphabetically. The number of specimens collected is given for each species up to four of each sex; for more, the terms *males* and *females* are used. The number of localities is also given up to 10, and *numerous localities* for more. Specimens of all species listed were deposited at the Science Service Laboratory, Kentville. Those indicated as having been collected by persons other than the writer were, however, unfortunately made unfit for reference purposes through desiccation.

Since the spiders of Nova Scotia have previously been studied little, the list provides extensions of the known ranges of many of the species.

### Family Theridiidae

- Achaearanea globosa* (Hentz). Three localities. Three males.
- Conopistha rufa* (Walckenaer). One locality. Two immature specimens.
- Dipoena nigra* (Emerton). One locality. One female.
- Enoplognatha* sp. One locality. One immature specimen.
- Oreonota americana* (Emerton). One locality. One immature specimen.
- Steatoda bipunctata* (Linnaeus). Three localities. Females.
- Steatoda borealis* (Hentz). One locality. One specimen. H. H. J. Nesbitt, 1945.

<sup>1</sup>Contribution No. 3462, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Assistant Entomologist.

- Theridion albidum* Banks. Numerous localities, never abundant. Two males, females. Maximum of two per tray by tapping method.  
*Theridion differens* Emerton. Ten localities. Two males, females.  
*Theridion frondeum* Hentz. Four localities. Females.  
*Theridion murarium* Emerton. Numerous localities, seldom abundant. Males, females. Maximum of five per tray by tapping method.  
*Theridion unimaculatum* Emerton. One locality. One female.  
*Theridula* sp. One locality. One immature specimen.

#### Family Linyphiidae

- Frontinella pyramitela* (Walckenaer). One locality. Two immature specimens.  
*Lepthyphantes alpina* Emerton. One locality. One female.  
*Meioneta angulata* (Emerton). One locality. One male.  
*Meioneta unimaculata* (Banks). One locality. One female.  
*Meioneta* sp., probably *fabra* Keyserling. One locality. One male.  
*Meioneta* sp. One locality. One male.  
*Pityohyphantes costatus* (Hentz). One locality. One female. F. T. Lord, May, 1947.

#### Family Erigonidae

- Ceraticelus emertoni* (O.P.-Cambridge). Six localities. One male, females.  
*Ceratinopsis nigriceps* Emerton. Four localities. One male, females.  
*Dismodicus decemoculatus* (Emerton). Two localities. Two females.  
*Eperigone trilobata* Emerton. One locality. One male.  
*Erigone atra* Blackwall. One locality. One male.  
*Erigone autumnalis* Emerton. One locality. One male.  
*Erigone* sp. One locality. One male, one female.  
*Hypselistes florens* (O.P.-Cambridge). Numerous localities, seldom abundant. Females. Maximum of five per tray by tapping method.  
*Podadicnemis pumila* Blackwall. One locality. One male.

#### Family Argiopidae

- Acanthepeira stellata* (Walckenaer). One locality. One immature specimen.  
*Araneus marmoreus* Clerck. Three localities. One male, females.  
*Araneus trifolium* (Hentz). Five localities. Two males, females.  
*Araneus* sp. Two localities. Two immature specimens.  
*Araniella displicata* (Hentz). Numerous localities, often abundant. Males, females. Maximum of 20 per tray by tapping method. Often observed feeding on Homoptera in trees.  
*Metepeira palustris* Chamberlin and Ivie. Three localities. Females.  
*Neoscona arabesca* (Walckenaer). Four localities. Males, females.  
*Zygiella atrica* (C. L. Koch). Six localities. Males, females.

#### Family Tetragnathidae

- Tetragnatha laboriosa* Hentz. Six localities. Females.  
*Tetragnatha versicolor* Walsknaer. One locality. One male.

#### Family Agelenidae

- Agelenopsis actiosa* (Gertsch and Ivie). One locality. One male.  
*Agelenopsis potteri* (Blackwall). Two localities. Two males, two females.  
Observed feeding on larva of the codling moth, *Carpocapsa pomonella* (L.), in tree.  
*Agelenopsis utahana* (Chamberlin and Ivie). One locality. One female.  
*Cicurina* sp. One locality. One immature specimen. H. H. J. Nesbitt, August, 1945.

*Coras montanus* (Emerton). One locality. One specimen. H. H. J. Nesbitt, August, 1945.

**Family Lycosidae**

*Pardosa moesta* Banks. Three localities. One male, two immature specimens.

**Family Gnaphosidae**

*Zelotes* sp. One locality. One immature specimen. F. T. Lord, June, 1947.

**Family Clubionidae**

*Clubiona moesta* Banks. Eight localities. Two males, females.

*Clubiona obesa* Hentz. One locality. One male. F. T. Lord, June, 1947.

**Family Anyphaenidae**

*Anyphaena* sp. Two localities. Two immature specimens.

*Wulfilia saltabunda* (Hentz). One locality. One male.

**Family Thomisidae**

*Coriarachne lenta* (Walckenaer). Numerous localities, never abundant. Females. Maxima of three per tray by tapping method and four per tree trunk by hand collecting. Observed feeding on larvae of the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), in trees.

*Misumena vatia* (Clerck). Numerous localities, seldom abundant. Males, females. Maximum of five per tray by tapping method. Observed feeding on larvae of the eye-spotted bud moth in trees.

*Philodromus cespiticolis* Walckenaer. Numerous localities, often abundant. Two males, females. Maximum of ten per tray by tapping method. Often observed feeding on Homoptera and Miridae in trees. This species has long been known to North American authors as *P. aureolus* (Clerck). A comparison of specimens with Palearctic forms (Locket and Millidge, 1951) of *aureolus* shows that the Nova Scotia specimens are all the same as the form *cespiticolis*, but distinct from typical *aureolus*. It is, in fact, distinct enough to be given species rank. Dr. W. J. Gertsch (personal communication) concurs in this opinion.

*Philodromus expositus* Keyserling. Three localities. One male, females.

*Philodromus placidus* Banks. One locality. One female.

*Philodromus rufus* Walckenaer. Numerous localities, often abundant. Males, females. Maximum of 15 per tray by tapping method. Observed feeding on Homoptera in trees.

*Synema obscurum* Keyserling. One locality. One male.

*Thanatus formicinus* (Clerck). Three localities. Three females. H. H. J. Nesbitt, 1945.

*Tibellus oblongus* (Walckenaer). Nine localities. Two males, females.

*Tmarus angulatus* (Walckenaer). Numerous localities, never abundant. Males, females. Maximum of three per tray by tapping method. Observed feeding on larvae of the eye-spotted bud moth in trees.

*Xysticus elegans* Keyserling. Four localities. Females.

*Xysticus gulosus* Keyserling. Two localities. Females.

*Xysticus punctatus* Keyserling. Numerous localities, never abundant. Females. Maxima of two adults per tray by tapping method and three per tree trunk by hand collecting.

**Family Salticidae**

*Admetina tibialis* (C. L. Koch). One locality. One male. F. T. Lord, August 1955.

*Euophrys monadnock* Emerton. One locality. One male. R. W. Walsh, June, 1947.

*Icius similis* Banks. Six localities. Females.

*Metaphidippus galathea* (Walckenaer). One locality. Two males. W. F. Chipman, June 1946. Observed feeding on larvae of the eye-spotted bud moth in trees.

*Metaphidippus protervus* (Walckenaer). Numerous localities, often abundant. Males, females. Maximum of four adults and subadults per tray by tapping method.

*Paraphidippus marginatus* (Walckenaer). Numerous localities, often abundant. Males, females. Maximum of seven adults and subadults per tray by tapping method. Often observed feeding on larvae of Lepidoptera and on Miridae, Homoptera, and small spiders in trees.

*Pellenes decorus* (Blackwall). One locality. One female.

*Pellenes boyi* (Peckham). Numerous localities, never abundant. Males, females. *Phidippus purpuratus* Keyserling. One locality. One male. H. H. J. Nesbitt, 1945.

*Phidippus rimator* (Walckenaer). Five localities. One male, females.

#### Family Dictynidae

*Dictyna annulipes* Blackwall. One locality. One male. F. T. Lord, July, 1946.

*Dictyna coloradensis* Chamberlin. Five localities. One male, females.

*Dictyna foliacea* (Hentz). Two localities. One male, one female.

#### Family Amaurobiidae

*Callobius bennetti* (Blackwall). One locality. One specimen. H. H. J. Nesbitt, 1945.

#### Acknowledgment

Dr. W. J. Gertsch, American Museum of Natural History, determined difficult species, confirmed determinations made by the writer, and assisted most generously in problems of nomenclature.

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**Laboratory Studies on Some Factors in the Life-history of the  
Predacious Mite *Typhlodromus tiliae* Oudms.  
(Acarina: Phytoseiidae)<sup>1</sup>**

By H. J. HERBERT<sup>2</sup>

Fruit Insect Section, Science Service Laboratory  
Kentville, Nova Scotia

Among the important predators of the European red mite, *Metatetranychus ulmi* (Koch), in Nova Scotia is a group of predacious mites belonging to the subfamily Phytoseiinae. There is little information in the literature on the biology of the species in this subfamily. Smith and Summers (1949) reported on the bionomics of "*Hypoaspis*" *macropilis* (Banks), and Herbert (1952) and Ballard (1953) on the life-history of *Typhlodromus fallacis* (Garm.).

Of the 14 species of the subfamily collected from apple trees in Nova Scotia (Herbert, 1952), *Typhlodromus tiliae* Oudms. is the most abundant and the most frequently found species. Although this species was collected largely from apple trees in Nova Scotia, I have also found it on cherry, plum, pear, maple, willow, choke-cherry, bean, raspberry, squash, and various weeds. Nesbitt's (1951) review of the taxonomic status of the Phytoseiinae includes a drawing and description of *T. tiliae*. He states that the species has been collected from the major fruit growing areas of Canada, Great Britain, and the United States.

This is a report on a laboratory study of some factors influencing the life-history of *T. tiliae*: effects of temperature and various amounts of food on rate of development, rate of oviposition, fecundity, and longevity. In Nova Scotia phytoseiid populations consist almost invariably of a mixture of several species. Since it is not possible to identify living individuals to species, it is necessary to rear specimens and, after obtaining progeny, to kill and mount the parents for identification. This limitation makes field observations on the life-history of phytoseiids very difficult. A laboratory study on the life-history of *T. tiliae* is not directly applicable to natural conditions, but data so obtained on the relative influence of such factors as food and temperature should provide useful information about the probable effects of these factors in the field.

**Materials and Methods**

In each of three series of tests, at  $70 \pm 2^\circ\text{F.}$ ,  $60 \pm 2^\circ\text{F.}$ , and  $50 \pm 2^\circ\text{F.}$ , the predator was fed daily with eggs of *Tetranychus bimaculatus* Harvey as follows: (a) 20 per nymph or adult; (b) 40 per nymph or adult; (c) 20 per nymph, the adults being given a superabundance of eggs of *M. ulmi* (Koch). In addition, at  $70^\circ\text{F.}$  nymphs were fed *M. ulmi* eggs. In each test, 20 males and 20 females were reared individually from the progeny of five overwintering female specimens of *T. tiliae*. The rearing chamber was a No. 2 pharmaceutical capsule placed inside a No. 000 capsule. The activities and development of the mites were readily observed with a binocular microscope in this type of chamber. The rearing chambers were placed inside a glass jar maintained at about 79 per cent relative humidity by a saturated solution of ammonium chloride. The glass jars were placed in cabinets with controlled temperatures. The predators were examined daily and the development was recorded. The food was placed in the short portion, or cap, of the capsule and fresh food was supplied daily by slipping the cap off the rearing chamber and replacing it with one containing the fresh food.

<sup>1</sup>Contribution No. 3459, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Assistant Entomologist.

### Results and Discussion

*T. tiliae* laid eggs readily in the capsules and development was apparently normal since 98 per cent of the eggs of females reared in them were viable. The time taken by the larvae to emerge from the eggs varied from three to ten minutes. The duration of the incubation period (in days) of *T. tiliae* eggs was as follows:—

Temperature .....	70°F.	60°F.	50°F.
No. eggs observed .....	268	197	30
Average .....	4.76	7.59	21.6

The mites were inactive in the larval stage and fed little if any. The duration of this period was short: one day at 60°F. and 70°F. and two to three days at 50°F. A marked change in activity occurred after the mites became protonymphs, and they began to feed voraciously. At 50°F. this stage lasted five days, at 60°F. two days, and at 70°F. one day. At 50°F. the protonymphs moulted and then died, presumably because they were unable to feed. The deutonymphal stage lasted from five to six days at 70°F. and nine days at 60°F. When the nymphs were fed eggs of *M. ulmi* at 70°F. they lived about four days. The males and females passed through one larval and two nymphal stages before becoming adults.

Mating took place soon after the last moult. The act took from four to six hours at 70°F. and 14 to 38 hours at 60°F. Of all the female predators reared only those that copulated laid eggs. The age of the females at the time of copulation ranged from 8 to 69 days and that of the males from 7 to 123 days. This suggests that under natural conditions females may copulate at any time and lay viable eggs. This may be an important survival characteristic. The males mated readily with more than one female. In one instance a male was confined with 16 females, all of which subsequently laid viable eggs. Mated and unmated individuals lived the same length of time.

Eggs were laid singly at irregular intervals of 1 to 24 days. When the females were fed 20 *T. bimaculatus* eggs per day the following were observed:—

Temperature .....	70°F.	60°F.
Pre-oviposition period (days) .....	8.25	11.57
Oviposition period (days) .....	61.0	76.84
No. eggs laid per female .....	15.05	15.32

When the amount of food consumed was increased to 40 eggs per day, the pre-oviposition period was shorter and the number of eggs laid per female increased:—

Temperature .....	70°F.	60°F.
Pre-oviposition period (days) .....	5.9	7.05
Oviposition period (days) .....	58.55	80.3
No. eggs laid per female .....	24.1	22.65

At 70°F., when the nymphs were fed 20 *T. bimaculatus* eggs per day and the adults a superabundance of eggs of *M. ulmi*, the pre-oviposition period averaged 10.68 days, the oviposition period 4.36 days, and the number of eggs per female 4.4.

The females lived considerably longer than the males, the lower temperatures increasing the longevity of both sexes. The number of *T. bimaculatus* eggs consumed had little effect on longevity, whereas the adults, after being reared through the nymphal stages on the eggs of *T. bimaculatus*, were short-lived when fed eggs of *M. ulmi*, the longevities in days being as follows:—

Temperature	70°F.	60°F.
Fed 20 <i>bimaculatus</i> eggs per day		
Males .....	41.3	74.9
Females .....	87.1	129.7
Fed 40 <i>bimaculatus</i> eggs per day		
Males .....	47.7	84.5
Females .....	83.6	132.5
Fed superabundance of <i>ulmi</i> eggs		
Males .....	14.9	
Females .....	34.55	

*T. bimaculatus* is easily reared in the greenhouse or laboratory and the eggs may be transferred to the capsules with little injury. The eggs of *M. ulmi* were extremely difficult to transfer without injury. Since the predators could not be reared in the laboratory as readily on the eggs of *M. ulmi* as on the eggs of *T. bimaculatus*, the results with the latter probably represent more nearly the effects of food and temperature. Although *T. tiliae* fed readily on the eggs of *T. bimaculatus* in the laboratory, they thrive on *M. ulmi* in the field.

A population of *T. fallacis* (Garm.) has been observed under natural conditions thriving in the presence of *Tetranychus* spp. and on a few occasions feeding on the eggs of *M. ulmi*. When this species was reared in the laboratory at 70°F. and consumed 20 *T. bimaculatus* eggs per day, *T. fallacis* developed more rapidly and laid a greater number of eggs than *T. tiliae*:—

Species	<i>T. tiliae</i>	<i>T. fallacis</i>
Incubation period (days) .....	4.76	2.7
Pre-oviposition period (days) .....	8.25	1.65
Oviposition period (days) .....	61.0	17.15
No. eggs laid per female .....	15.05	44.0
Longevity Males .....	41.3	12.1
Females .....	87.1	40.5

#### Summary

*Typhlodromus tiliae* Oudms. is the most abundant and most frequently found species of phytoseiid on apple trees in Nova Scotia. Data are presented on the durations of the immature stages, the lengths of the pre-oviposition and the oviposition periods, the number of eggs laid per female, and the longevity as influenced by such factors as temperature and amounts of food under controlled laboratory conditions. When *T. tiliae* was maintained at 70°F. and consumed 20 eggs of *T. bimaculatus* per day, a generation was completed in 13 days, but at 60°F., with other conditions constant, a generation was completed in 19 days. When 40 eggs of *T. bimaculatus* were consumed per day, at 70°F. a generation was completed in 10.6 days, and at 60°F. in 15.6 days. At 60°F. and 70°F. females lived considerably longer than the males. At 70°F., when 20 eggs of *T. bimaculatus* were consumed per day *T. fallacis* developed much more rapidly than *T. tiliae*.

#### Acknowledgments

I am indebted to the other officers of the Kentville laboratory and to Dr. H. H. J. Nesbitt, Carleton College, Ottawa, for assistance.

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### Some Parasites and Predators of *Pseudaulacaspis pentagona* (Targ.) in Trinidad, B.W.I.

By FRED D. BENNETT

Commonwealth Institute of Biological Control

*Pseudaulacaspis pentagona* (Targ.) was first observed in Bermuda in 1917. By 1920 infestations severe enough to cause defoliation of oleanders were recorded. Damage by the scale increased despite an intensive spray programme until the establishment of *Aphytis diaspidis* (How.) from Italy in 1921-24. (Ogilvie, 1928). For several years this Aphelinid kept the scale under satisfactory control, only small sporadic outbreaks occurring from time to time. In recent years however, outbreaks have been severe enough to warrant a detailed investigation (Simmonds, 1955).

As part of the programme for obtaining parasites and predators to increase the degree of control effected by *Aphytis*, an investigation was undertaken in Trinidad in March 1955. Here the scale occurs on a number of host plants but has not been seen on oleander. Among the plants it attacks are the following, listed more or less in the order of frequency of attack: *Stachytarpheta cayennensis* (L. C. Rich) Vahl., *Carica papaya* L., *Solanum melongena* L., *Lantana camara* L., *Lochnera rosea* (L.), *Solanum* sp., and *Urena lobata* L.

The scale is seldom abundant enough on cultivated plants to be rated as more than a pest of minor importance. However, the pasture weed *Stachytarpheta cayennensis* is severely attacked, and towards the end of the dry season a heavy infestation, coupled with lack of moisture, frequently causes complete defoliation.

The scale breeds throughout the year with no apparent seasonal variation in the life-cycle such as occurs in Bermuda where it is appreciably lengthened during the cooler winter months.

There is a slight but definite increase in the scale population in Trinidad towards the end of the dry season. This increase is difficult to evaluate accurately because of seasonal variations in the density of the foliage of host plants. At the end of the dry season, the foliage of most plants is much more sparse than it is during the wet season. For this reason, even a constant scale population may appear to increase during the dry season.

The factors influencing the slight increase in population are not known. Possibly the dry season renders plants more susceptible to attack, whereas the heavy rains favour the growth of the plant and at the same time discourage many of the scale crawlers from settling. Furthermore, the scale may be checked to some extent by entomophagous fungi which are favoured by the humid conditions prevailing during the rainy season but suppressed by the lack of moisture in the dry season. Insect parasites and predators are most abundant towards the end of the dry season and it is possible that they then exert their maximum degree of control, causing a drop in scale population shortly afterwards.

Three species of parasites and at least eight species of predators are associated with *Pseudaulacaspis pentagona* in Trinidad. The parasites are *Aspidiotiphagus citrinus* (Craw.), *A. lounsburyi* (Berlese and Paoli.) and *Aphytis* sp. *proclia* group.

*Aspidiotiphagus citrinus* is most abundant, outnumbering the other species by at least fifty to one in most collections. It breeds readily in the laboratory, developing as an internal parasite in young scales. Both male and female scales are attacked. The scale continues to develop for a few days before the developing parasite larva kills it. Adults emerge eighteen to twenty days after the date of attack. *Aspidiotiphagus lounsburyi* was present only in part of the collections and was never very numerous. Both of these species are already present in Bermuda.

*Aphytis* sp. *proclia* group develops as an ectoparasite of medium and large scales including ovipositing females. The taxonomy of the genus *Aphytis* is extremely difficult as there are many "races" which are indistinguishable morphologically but can be separated by biological differences. In his recent revision of the genus *Aphytis* Compere (1955) did not discuss specimens from either Trinidad or Bermuda. However, in his key, the Bermuda specimens referred to above as *A. diaspidis* do not run to *diaspidis* but appear to belong near *maculicornis* or *bovelli*. Specimens from Trinidad run to the same section of the key but it is not known whether the Trinidad and Bermuda forms can be separated by morphological differences. Until this problem has been solved it is preferable to refer to the specimens from Trinidad as *Aphytis* sp. *proclia* group (Trinidad strain) and those from Bermuda as *Aphytis* sp. *proclia* group (Bermuda strain). It is of interest to note that whereas *Aphytis* is abundant in Bermuda it is comparatively scarce in Trinidad.

The predators associated with *Pseudaulacaspis* are *Chilocorus cacti* L. *Coccidophilus citricola* Brethes, *Cryptognatha simillima* Sic., *Cryptognatha nodiceps* Mshl., *Cryptognatha* sp., *Pentilia insidiosa* Muls., *Neaporia* sp., nr. *gorhami* Brethes (all Coccinellidae) and *Cybocephalus* sp., (Nitidulidae). These determinations were kindly supplied by R. D. Pope, British Museum (Natural History).

It is difficult to assess the relative value of the various species of predators. In numerical abundance the order appears to be *Cybocephalus* sp., *Cryptognatha simillima*, *Pentilia insidiosa*, *Coccidophilus citricola* and *Chilocorus cacti*, with the remaining species being collected only occasionally on this host. Of these, *Chilocorus cacti* and *Cybocephalus* sp. already occur in Bermuda, the former being established from Jamaica in 1951 and the latter introduced from shipments of miscellaneous scale-feeding predators from Trinidad in 1948 and 1951. *Cryptognatha nodiceps*, *C. simillima* and *Pentilia insidiosa* were also liberated at this time but did not become established. Of the remaining species, *Coccidophilus citricola* would appear to be most useful. Because of its small size it should be able to breed on relatively light infestations of the scale.

All the above mentioned predators were liberated in Bermuda from a series of shipments in 1955 but no recoveries have been made except of the species previously established.

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**Two New Species of the Genus *Cinara* Curtis (Homoptera: Aphididae) from *Picea mariana* (Mill.) B.S.P.<sup>1</sup>**

By G. A. BRADLEY

Forest Biology Laboratory, Indian Head, Sask.

***Cinara mariana* n. sp.**

*Apterous viviparous female*

General colour of body brown. In cleared specimens, the following parts are dark brown: head; thorax; cornicles; muscle attachment plates; spiracles; terminal segments of rostrum, including the distal portion of segment II; coxae; femora, except short areas near the bases; short distal portions, and short, indistinct areas at the bases of the tibiae; tarsi; antennal segments I and VI, and the distal half of IV and V. The remaining parts of the body and appendages are light yellowish-brown. The setae are long and numerous, giving the cleared specimens a conspicuously hairy appearance.

Measurements: Body length about 2 mm., width about 1.22 mm. Width of head across eyes .61. Antenna, total length .85 to .95, segments, III .26; IV .15; V .17; VI .12 and .04. Hind tibia, length 1.15, diameter .07. Lengths of hind tarsal segments, I .10; II .28. Rostrum reaches middle of abdomen. Lengths of rostral segments, III .17; IV .16; V .07. Diameter of cornicle base .36. Length of setae, on antenna .11, on hind tibia .14, on dorsum of abdomen .11.

Sensoria: On antennal segments, III, 0; IV, 1; V, 2; VI, 7. There are two secondary subapical and eleven basal setae on antennal segment VI.

*Alate viviparous female*

Colour of body and appendages similar to that of the apterous female except that most of the antenna is dark brown, only segment II and basal portion of III being light brown.

Measurements: Body length about 2.64 mm., width about 1.22 mm. Width of head across eyes .64. Antenna, total length 1.12, segments, III .41; IV .17; V .19; VI .16 and .05. Hind tibia, length 1.34, diameter .07. Lengths of hind tarsal segments, I .10; II .28. Rostrum reaches just beyond hind coxae. Lengths of rostral segments, III .18; IV .16; V .08. Diameter of cornicle base .37. Length of setae, on antenna .10, on hind tibia .15, on dorsum of abdomen .09.

Sensoria: On antennal segments, III, 1; IV, 2; V, 2; VI, 7. There are two secondary subapical and eleven basal setae on antennal segment VI.

*Host*

*Picea mariana* (Mill.) B.S.P., black spruce. Found on bark of the small twigs, on the new growth.

*Holotype*

Apterous viviparous female. Collected August 3, 1955 from black spruce on south shore of Waskesiu Lake, Prince Albert National Park, Saskatchewan. Type deposited in the Canadian National Collection, Ottawa.

This species is somewhat similar to *Cinara vandykei* (Wilson) but differs in having longer setae on the hind tibia, .14 compared to .10 in the apterae; hind tibia shorter, 1.34 compared to 1.7 in the alatae; hind tibia mainly yellowish-brown, not dark brown with a yellowish area near base as in *C. vandykei*. The length of the body and appendages are generally less in *C. mariana* than in *C. vandykei*, but the unguis is longer in *C. mariana*. The males are alate in *C. mariana* and apterous in *C. vandykei*.

<sup>1</sup>Contribution No. 305. Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

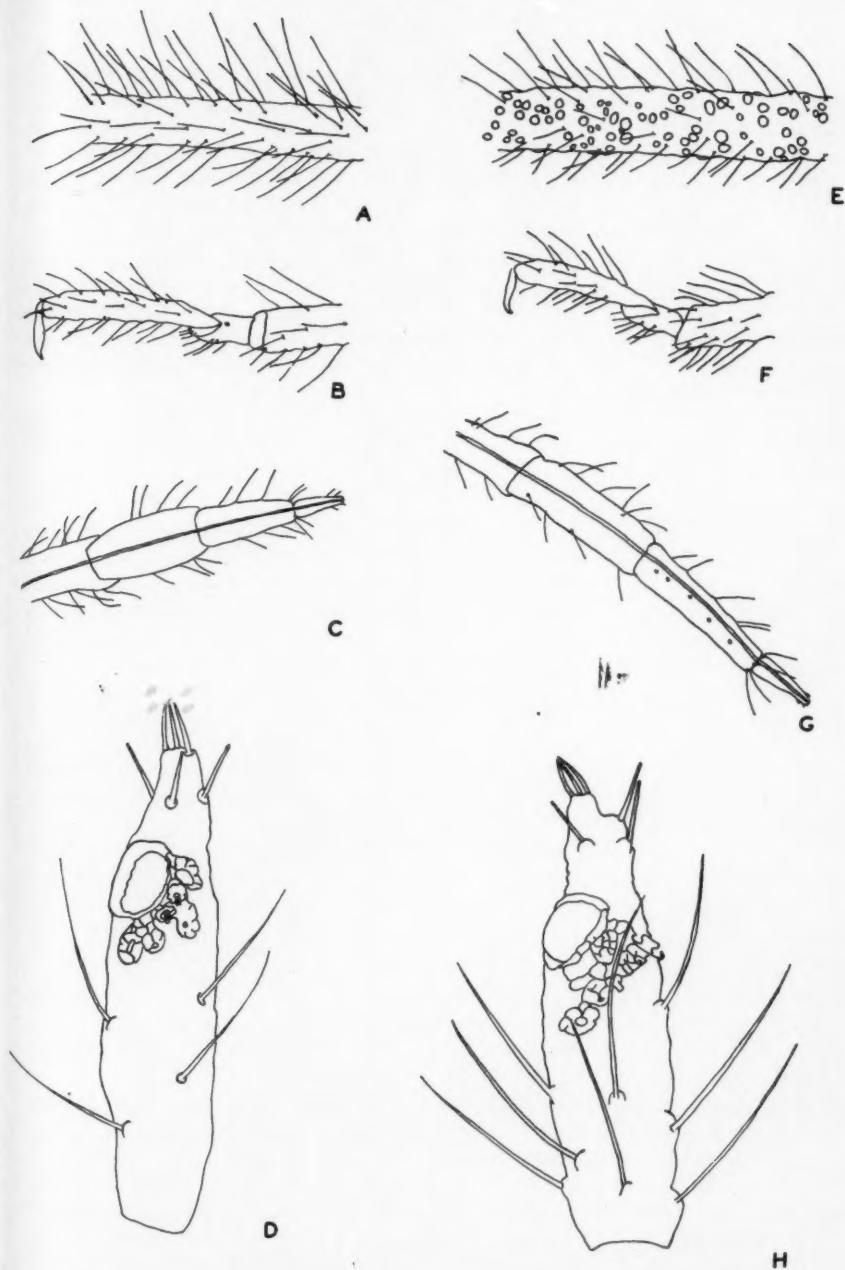


Fig. 1. A to D, apterous viviparous female, *Cinara mariana*; E to H, oviparous female, *C. rara*. A, E, section of hind tibia; B, F, hind tarsus; C, G, rostrum; D, H, antennal segment VI.

*Cinara rara* n. sp.*Oviparous female*

General colour of body and appendages brown. In cleared specimens, the following are dark brown: head and thorax; muscle attachment plates; spiracles; cornicles; cauda; genital plate; eyes; antennal segments I and II, and the distal portions of III, IV and all of V; coxae; trochanters; short distal portion of pro-, meso-, and entire metathoracic tibiae; tarsi; terminal segments of rostrum, including the distal portion of II. Remainder of body and appendages light yellowish-brown. The body and appendages have numerous long, fine setae.

Measurements: Body length about 2.78 mm., width about 1.82 mm. Width of head across eyes .68. Antenna, total length 1.09, segments, III .34; IV .16; V .21; VI .14 and .04. Hind tibia, length 1.28, diameter .09. Lengths of hind tarsal segments, I .08; II .22. Rostrum reaches cornicles. Lengths of rostral segments, III .23; IV .24; V .09. Diameter of cornicle base .29. Length of setae, on antenna .10; on hind tibia .12; on dorsum of abdomen .11.

Sensoria: On antennal segments, III, 0; IV, 0; V, 2; VI, 7. Numerous small circular sensoria on the hind tibia. There are two secondary subapical and thirteen basal setae on antennal segment VI.

*Male*

Alate. General body colour slightly darker brown than the oviparous female. The appendages of cleared specimens are similar in colour to those of the female, with the following exceptions: the antennae are dark brown, except for a short lighter area at the base of III; legs mainly dark brown, except for pale areas at the bases of the pro- and metathoracic femora, and faint light areas near the bases of the metathoracic tibiae.

Measurements: Length of body about 2.03 mm. Width of head across the eyes .62. Antenna, total length 1.19; segments, III .32; IV .19; V .23; VI .15 and .05. Hind tibia, length 1.33, diameter .05. Lengths of hind tarsal segments, I .08; II .21. Rostrum extends beyond the cornicles. Lengths of rostral segments, III .21; IV .21; V .09. Diameter of cornicle base .29. Length of setae, on antenna .08, on hind tibia .10, on dorsum of abdomen .07.

Sensoria: Numerous circular, protruding sensoria on III and IV; V, 4; VI, 7. There are two secondary subapical and thirteen basal setae on antennal segment VI.

*Host*

*Picea mariana* (Mill.) B.S.P., black spruce.

*Holotype*

Oviparous female. Collected by B. McLeod at Lac la Ronge, Saskatchewan, September 1955, from black spruce. Type in the Canadian National Collection, Ottawa.

This species is similar in size and general appearance to *C. mariana*, but differs markedly in the length of the rostrum, that of *C. rara* extending to or beyond the cornicles whereas the rostrum in *C. mariana* barely reaches the middle of the abdomen. The rostral segments are longer in *C. rara*, segment IV .23 compared to .16 in *C. mariana*. The tarsal segments are shorter in *C. rara*, hind tarsal II .22, compared to .28 in *C. mariana*.

